Devising a unique model for science outreach programmes with critical engagement from teachers across the 5-19 age range

Victoria Kate Brennan

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ABSTRACT

This thesis utilises teachers' reflections regarding their experiences of science outreach activities, they have encountered and identify features of these programmes that attracts schools to engage (or not engage) with these extra-curricular events. This is useful as science outreach work is considered a fun and satisfying venture which can enhance the learning experience, spark scientific interest in learners which can promote further engagement within the subject (Shanahan et al, 2011). Teachers are also an important group to focus upon within this field, as teachers are gatekeepers to these experiences. However, wider research warns that there is little evidence to suggest whether these types of activities achieve their overarching goal; to encourage people to enter and persist within science careers (Banerjee, 2018; Bogue et al, 2013; Van De Hurk et al, 2019). Therefore, this PhD aims to further explore which type of outreach activities participants believe to be the most successful in enthusing learners in science, to provide recommendations as to the future designs of these programmes.

To do so, this PhD was divided into two Phases and collected data from participants across all formal educational levels (eg. from primary to college in the context of England). Phase One involved conducting questionnaires (*n*=52) and interviews (*n*=8) and generated both quantitative and qualitative data. Standard statistical analysis was used to determine who participants felt that science outreach should be aimed at and thematic analysis (Braun and Clarke, 2006) of the qualitative data provided a more detailed understanding of what teacher's expectations are with regards to these programmes. Data revealed that despite wider research stating that children formed interests at a young age (Oppermann et al, 2018), participants felt that outreach was more important at higher educational levels. Participants did however agree that it was of equal important for both genders and those from a lower socio-economic background. Responses from the open-questions and interviews also revealed that although teachers value these types of activities to assist with the formal science curriculum, barriers such as time and cost may limit their engagement with these programmes. These findings, along with more focused wider literature, were then used to develop a preliminary model for the 'optimum' delivery of science outreach activities.

Phase Two was designed to further refine the proposed model using principles of Modified Grounded Theory via conducting focus groups (*n*=4). As part of these focus groups participants were also specifically asked which aspects of the model would be most beneficial for those learning from lower socio-economic backgrounds. Findings from this phase of the PhD study indicated that the key to effective outreach work in science is to ensure that clear objectives are defined at the start of the design process to ensure that all key stakeholders such as teachers, parents and learners are included. It is anticipated that if this approach to developing outreach activities in science is adopted it will assist with removing some of the barriers to engaging with these events to increase engagement. Participants also perceived that by focusing on careers, making science relevant to the learners, providing relatable role models and engaging parents in science outreach events, would make these programmes more impactful, especially for those learners from disadvantaged background.

When designing this model, a pragmatist approach was adopted as this allowed the researcher to focus on the strengths of the different paradigms (Johnson & Onwuegbuzie, 2004). This ensured that the data collected provided the most suitable information to create the 'optimum science outreach model for lasting impact' which translates data into a framework. Using this model as a framework will allow outreach providers to draw upon findings from this study more readily when designing age-appropriate outreach activities. Thus, this PhD provides further understanding as to what motivates teachers to engage with science outreach activities, which can be used to inform the design of subsequent programmes.

DEFINITIONS

APPG	All-Party Parliamentary Group
BTEC	Business and Technology Education Council
C21	21st Century science
CETL	Centres for Excellence in Teaching and Learning
CPD	Continued professional development
DBIS	Department for Business, Innovation and Skills
DfE	Department for Education
DfE	Department for Education
EEF	Education Endowment Foundation
EOp	Equality of opportunity
FE	Further Education
FG	Focus groups
FSM	Free school meals
GCSE	General Certificate of Secondary Education
GT	Grounded Theory
GTM	Grounded Theory Method
HE	Higher education
HEI	Higher Education Institute
KS	Key Stage
LJMU	Liverpool John Moores University
MFL	Modern foreign languages
mGT	Modified Grounded Theory
MMR	Mixed Methods Research
NFER	National Foundation for Educational Research
NW	North West
PGR	Postgraduate researcher
PP	Pupil premium
RSC	Royal Society of Chemistry
SATs	Standard Assessment Tests
SDT	Self-determination theory
SES	Socio-economic status
SET	Science engineering and technology
SiS	Scientist in Schools
STEAM	Science, technology, engineering, arts and mathematics
STEM	Science, technology, engineering and mathematics
STF	Science teacher fellow
TA	Thematic analysis
TIMMS	Trends in International Mathematics and Science Study
WP	Widening participation

DECLARATION

I declare that no portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this at any other university or institute of learning.

PUBLICATIONS

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CHAPTER 1:

INTRODUCTION

The aim of this chapter is to introduce the main research study aims and questions that this Doctoral project will explore. To frame the research questions, there is a brief discussion regarding science education and the purpose of science outreach work. Understanding the current issues in science education allows the researcher to frame the importance of science outreach as a tool to assist formal education. Within the study, there is a particular focus on how outreach initiatives are of particular importance for learners from a lower socio-economic background; this is supported by wider theories form literature that are introduced in this chapter and are explored in further detail in Chapter 2. Throughout this thesis, the terms 'learner', 'children/child', 'pupil' and 'young person' are used interchangeable to assist with the flow of the writing. These terms however are all used to define an individual who is of formal school age.

1.1 THE FORMAL SCIENCE CURRICULUM

Science is deemed a compulsory subject in many countries, however, there continues to be changes in what is taught and the pedagogy on how to teach it (Donnelly, 2006; Fensham, 2013; Ryder, 2015). Fenham (2009) discusses how these changes are often governed by the multiple stakeholders who present different demands upon teachers and have varying degrees of influence. Wong (2019) advocates having a clear understanding of the changes in the science curriculum as they can shape a learner's own experience of science, which can impact upon their future perceptions towards the subject. Different priorities have been emphasised over time such as, focusing on the nature or history of science, social impacts of science or the amount of science content.

Thus, Fensham (2009) suggests that education policies in schools are derived from values which may shift over time. Whilst this is to be expected as countries change due to political and economic reforms, Wong (2019) emphasises that different groups in society will present different values regarding science education and the decision as to whose values to uphold may advantage or disadvantage these groups. This is important within the context of this study, as an individual's success at school in England, is measured by their ability to perform well in examinations, which is a measure of their understanding of the current curricular; thus, a learner's success may influence their enjoyment of the subject (Braund, 2009; Maltese and Tai, 2010; Rodd et al, 2013).

1.1.1 Who is science for?

When considering the approach to teaching science at school Thomas & Banks (2009, p.6) describe how school science is simply an "operation of the scientific method" in which practical work is carried out to model a scientist's work (Hodson, 2008). This model of teaching science in schools is deemed important for those pupils wishing to become scientists. Although, Millar (2002) warns that this approach to learning in science will provide no benefits for the individual when trying to tackle 'real-life' problems scientifically. This holds the curricula responsible for responding to the needs of all learners, with the intent to recognise these formal scientific concepts learnt at school and the developing world around them. In England, where science is a statutory subject across the primary and secondary educational settings, the Department of Education (DfE) (2013) governs what is taught in schools. The documentation describes how science should feed the curiosity of phenomena of the world around us using models and experiments; allowing all learners to appreciate science can contribute to change in our lives and the world around (DfE, 2013). Whilst this does allude to supporting the needs of different learners, Wong (2019) discusses how the purpose of science education remains focused on encouraging more people to study science thus, focussing upon the 'few'.

1.1.2 The changing shape of school science in England

Historically, the Beyond 2000 document (Millar & Osbourne, 1998) is widely recognised as an important report that prompted discussion regarding the multiple purposes of science education. It discussed how science should support those who continue to study science beyond school, whilst also promoting scientific literacy and generating curiosity for all (Wong, 2019). It was anticipated that these changes needed to occur to maintain the attention of pupils in science. Horner (2011) and Toplis et al (2010) expressed how they hoped that aspects of this formal curriculum (DfE, 2013) such as 'working scientifically' and 'How Science Works' would develop the scientific literacy of the individual and contextualise learning inside the science classroom. The Gatsby Foundation (2017) describe how these aspects of the curricula focus on developing pupils' skills in science, as these experimental opportunities are what builds scientific identity.

At GCSE level, a new specification entitled 21st Century Science (C21) aimed to provide a 'worthwhile and inspiring' experience of science at school, regardless of whether pupils wished to become professional scientists or not (Nuffield foundation, n.d.). The design of the C21 specification, emphasises the need for a "concept led teaching approach to science", allowing pupils to engage with science encountered in everyday life whilst preparing them for science-based careers (OCR, 2011, p.3). This approach to teaching science has been linked to rising numbers of pupils pursuing science A-levels (Stutchbury et al, 2011). However, there are many criticisms of the C21 course especially by teachers, these include a lack of practical work, the pedagogical approaches and the style of questioning utilised.

In comparison, other GCSE specifications focus on practical work and critical skills to support scientific explanations (OCR, 2011). Holman (2009) states that during science examinations the amount of mathematical content and the quality of examination questions were the main issues, not the key concepts of the science which were the same. Mathematical content in science is important to consider as, research regarding the uptake of science subject's Post-16 (aged 16 plus), often considers mathematical ability to be a 'critical' factor when deciding if to continue studying science or not (Schoon, Ross and Martin, 2007).

The reform of the science GCSEs in 2016, aimed to address this concern, as the mathematical content was increased and specified as part of the examination courses in all science disciplines. As part of GCSE reform, 'required practical' became a compulsory aspect of both GCSE and Post-16 A Level study, but unlike previous courses these skills will be assessed within an exam, rather than as a piece of coursework (Ofqual, 2015). There has also been changes to the content, structure and grading system of these assessments in science, resulting in teachers being particularly concerned about the amount, and types, of 'required practical' experiments now included in the specification (Wilson, Wade and Evans, 2016). Burgess and Thomson (2019) found that the reform to the GCSE examinations, which included a new grading system (as opposed to awards A*-G scores), meant that there was a slight 'drop' in the number of GCSEs students studied however, on average all students received passes (these would be classed as receiving a grade 9-4). However, when looking at these statistics in terms of the attainment gap between advantaged and disadvantaged students, this gap increased slightly overall, with science being a particular subject that was noted as, a "strong pattern…in widening the test score gap" (Burgess and Thomson, 2019, p.22). Thus, the assessment reform in 2016 in England, adds to the further concerns addressed in section 1.2. It also demonstrates how teachers need to be well equipped for a range of initiatives and innovations throughout their careers (Liversidge, 2009), to be flexible and meet the changing needs of their science learners.

1.2 ADDRESSING CONCERNS REGARDING THE UPTAKE OF POST-COMPULSORY SCIENCE

The Science and Technology Committee (STC) (2017) acknowledged that there is a shortage of technical-level skills, with a particular concern about science, technology, engineering and maths (STEM). This Green Paper outlined that the UK ranked 16th out of 20 OECD countries for the proportion of people with STEM qualifications and nearly 40% of UK employers report difficulties recruiting staff with relevant STEM skills (STC, 2017). Amongst the concerns about the general uptake of science, is the fact that those who apply for sciences (not just "hard" sciences such as physics or chemistry) are more likely to do so if their profile shows a higher occupational class (Gorard and See, 2008, p.217). It is therefore to be considered that some social groupings appear to be underrepresented within the science profession (Anderhag et al, 2013). Tobin (2004, p. 191) agrees that "home is also a factor that can either foster or inhibit the learning of science." Socio-economic status (SES) or 'home' refers to a young person's family background in the context of occupations, educational qualifications and income. At school in England, this social disadvantage is often measured by whether the child is in receipt of 'pupil premium' (PP) (see chapter 2.2.1) due to their family's low SES and thus are entitled to free school meals (DfE, 2020).

The socio-economic gap of those choosing to study science does not derive from educational Key Stage 5 (KS5 – Post-16 education) but much earlier; most pupils would not apply for related courses at a Higher Educational (HE) Institute if they were not previously studied at a foundation level/Level 3. For example, at the end of KS4 (13-16 year olds), which is compulsory school for all students in England, pupils will make choices regarding their own future. However, if they wish to pursue a career in science then it is likely A-levels will be chosen in the sciences (often with mathematics), as these qualifications are necessary to study an undergraduate science course (Gill and Bell, 2013).

Although these decisions are made at the end of high school (11-16 year olds), Harlen (2008) suggests that perceptions of a subject may arise earlier, describing how ideas often develop at a very early age, as a child begins to explore and engage with the world around them. This reflects a study conducted by Rodd et al (2013), which researched 'unconscious forces', drawing on the work of Sigmund Freud, as to reasons behind an individuals' choice about their future. Frost (2006, cited in Rodd et al, 2013) explains how these 'forces' may be emotions or motivations, that influence behaviours that the person themselves are not aware of and which may derive from a variety of social factors.

Oppermann et al (2018) further support the notion of beliefs regarding science and being a science learner. They discuss how learners as young as 5-6 years old form opinions about science, due in part to a natural curiosity regarding the world around them. Therefore, these 'forces' or 'beliefs' "are considered important precursors of learner's future motivation to pursue science" (Oppermann et al, 2018, p.399).

Gorard and See's (2008) paper, aimed to consider ideas that link to the issues explored above. It is evident that the SES of a learner has an impact upon their decisions in choosing to study science, although these decisions may be linked to earlier experiences and attainment in science. This is further highlighted in a report by CASE (2014) that recognised 30% of young adults accessing University placements originate from socio-economically deprived areas; however, the representation in chemistry, maths and physics is lower. More recent data from Cadwallader (2019) supports these earlier discrepancies as they found that if a child was from a disadvantaged background (such as a low SES, or minority race or gender) then they were less likely to have a sustained destination within further education or apprentices (85%), compared to their more affluent counterparts (93%). Attainment in GCSE English and mathematics, can impact upon the likelihood of a sustained destination, although middle and high attaining disadvantaged students are often less likely to continue in the school's sixth form or at a sixth form college and chose more vocational routes. Therefore, all experiences across all key stages have an impact upon Post-16 choices, but within the research there is wealth of studies who place a particular focus on science (see Chapter 2.2)

Along with SES, other social groups based on gender, ethnicity, language, disabilities, sexual orientation and location are still at risk of being disadvantaged by how science (as part of the STEM agenda) operates within the current school system (APPG on Diversity and Inclusion in STEM, 2020). This report suggests that inequity in STEM education derives from when and where an individual goes to school, parental influence and stereotypical role-models. These ideas can be linked to the concept of an individual's 'science capital' which derives from Bourdieu's (1977) theory of cultural capital and habitus within a particular field (Godec, King and Archer, 2017). Bourdieu (1977) proposed that some learners are more comfortable within the school environment and therefore, are more likely to succeed and feel more valued. According to Mufti (2009), this idea of being 'comfortable' is linked to learners who find a school environment 'more natural' due to parents and families who have a privileged insight and promote these values of education. Science capital (Archer et al, 2015) draws upon these ideas of 'habitus' or 'attitudes' that form from an individual's access to science resources such as materials, quality of instruction and role models they know (Godec et al, 2017). If a younger person has a lower level of 'science capital' then they are less likely to believe that they themselves are a 'science-type-of-person' which will reduce their aspirations to continue studying science.

1.3 HOW CAN SCIENCE OUTREACH PROGRAMMES HELP?

Shanahan et al (2011) argue that science outreach programmes aim to support teachers and promote scientific literacy, whilst providing pivotal opportunities to spark scientific interests in students increasing their awareness of career opportunities. This notion is globally recognised by the national organizations for science, including the Natural Sciences and Engineering Research Council for Canada (2008) and the National Science Foundation (2008) in the United States, which encourage the partnership between scientists and schools. These ideas also transcend countries, as similar themes and objectives of outreach programmes are exemplified in the description provided by the Royal Society of Chemistry (RSC, 2016, para 2) who "support a broad range of activities to inspire and enthuse the next generation with chemistry" and "offer school students the opportunity to engage with practising chemists and learn about the application of the chemical sciences in the real world." Some examples of science outreach activities developed by the RSC include, 'I'm a scientist get me out of here', 'Spectroscopy in a Suitcase' and 'Chemists at Work'. Other examples of science outreach practices include STEM clubs, public lectures, 'Big Bang' shows and trips to museums and science centres.

Additionally, Bogue, Cady and Shanahan (2013) describe how outreach work provides an opportunity for members of different societies to develop leadership skills whilst promoting their own community to those beyond the usual membership. Outreach can also be described as a fun and satisfying venture. However, Bogue et al (2013) warn that there is little evidence verifying whether outreach activities achieve their overarching goal, to encourage people to enter and persist within the field of STEM beyond the age of compulsory school education.

1.3.1 WHAT ARE SCIENCE OUTREACH PROGRAMMES?

It is described how outreach programmes provide process and/or activities to be able to bring information or services to a wider audience and using strategies beyond the usual limits (Vennix et al, 2018). Science outreach in particular can also be encapsulated under an umbrella of informal science learning (ISL) programmes, which have been found to provide valuable opportunities for individuals to learn about science and further engage with the subject (Archer and DeWitt, 2017). Gall et al (2020) and Van Den Hurk et al (2019) further suggest that science outreach also has the goal of serving underrepresent groups in STEM. These ideas align with Banerjee (2018), who explains how HEIs in particular have social responsibilities to develop these widening participation outreach programmes to further diversify those accessing Higher Education. Thus, in the context of science, outreach programmes may include activities such as science clubs, talks, trip, hands-on activities, workshops etc. that are an "addition to the regular curriculum" (Vennix et al, 2018 p.1264). Whilst a level of flexibility in these programmes is preferable to be able to meet the changing demands of science curricula, Gall et al (2020) suggest that there needs to be further consideration for the purpose of the outreach tool, as Vennix et al (2018) agrees that there is still no consensus as to which outreach interventions are successful in raising interest or persistence in STEM education.

Although there is a call for further research regarding the impact of these outreach programmes in the context of future choices in science, it was found that science outreach programmes that focus on developing science knowledge, ability, motivation and developing a sense of belonging can increase interest in STEM (Van den Hurk et al, 2019; Vennix et al, 2018). Kang et al (2019) also describe how science outreach programmes can provide further understanding of STEM based careers and provide memorable experiences that go beyond the school environment. Therefore, these experiences and information not only adds value to an individual learners' education, but for some groups of disadvantaged learners it can help to narrow some opportunity gaps which Morgan et al (2016) identify are more common for individuals from a families of a lower SES.

1.3.2 Placing research within a conceptual framework

When attempting to align this research within a conceptual theoretical framework, there are several theories that could be considered regarding pupils' choices in science, with a focus upon those individuals from a lower socio-economic background. The theories that underpin this study, are discussed in Chapter 2, along with further detail discussing the developmental-contextual model of career development.

Cridge and Cridge's (2015) narrative review of the engagement of universities with school science, suggest that a combination of parents, teachers, peers and role models can influence the choices of an individual. Many of their ideas regarding parents, link to family background; they describe how important mothers have been to influence their child's self-belief, when choosing a particular career pathway. These findings support the research of Schoon et al (2007) who analysed destinations of two cohorts of students from 1958 and 1970. They found that for women, a strong indicator of whether a person would choose to enter a science, engineering or technology (SET) career was linked to the educational background of the child's mother. In their further research, they provide a diagram (see Figure 1-1) of their findings which explored different intrinsic and extrinsic factors that could impact upon an individuals' career choice.

It is visible from Figure 1-1 that 'parental socio-economic status (SES)' and 'school experiences', may have an indirect influence on an individuals' sense of self; thus, linking relevant themes of how home and school may have an impact on science beliefs and future choices. In terms of where science outreach programmes could 'fit' within this model, Schoon et al (2007) describe how the school environment may be a powerful factor when it comes to the career development of children. They discuss how school accounts for an individuals' exposure to science and how experiences at school may compensate for the disadvantage of being from a background where opportunities may be few, or where schools provide support that is not available at home. Therefore, when considering the 'responsibility' of the school, their involvement with outreach programmes, which are there to enhance the school experience, may be able to assist with this role.

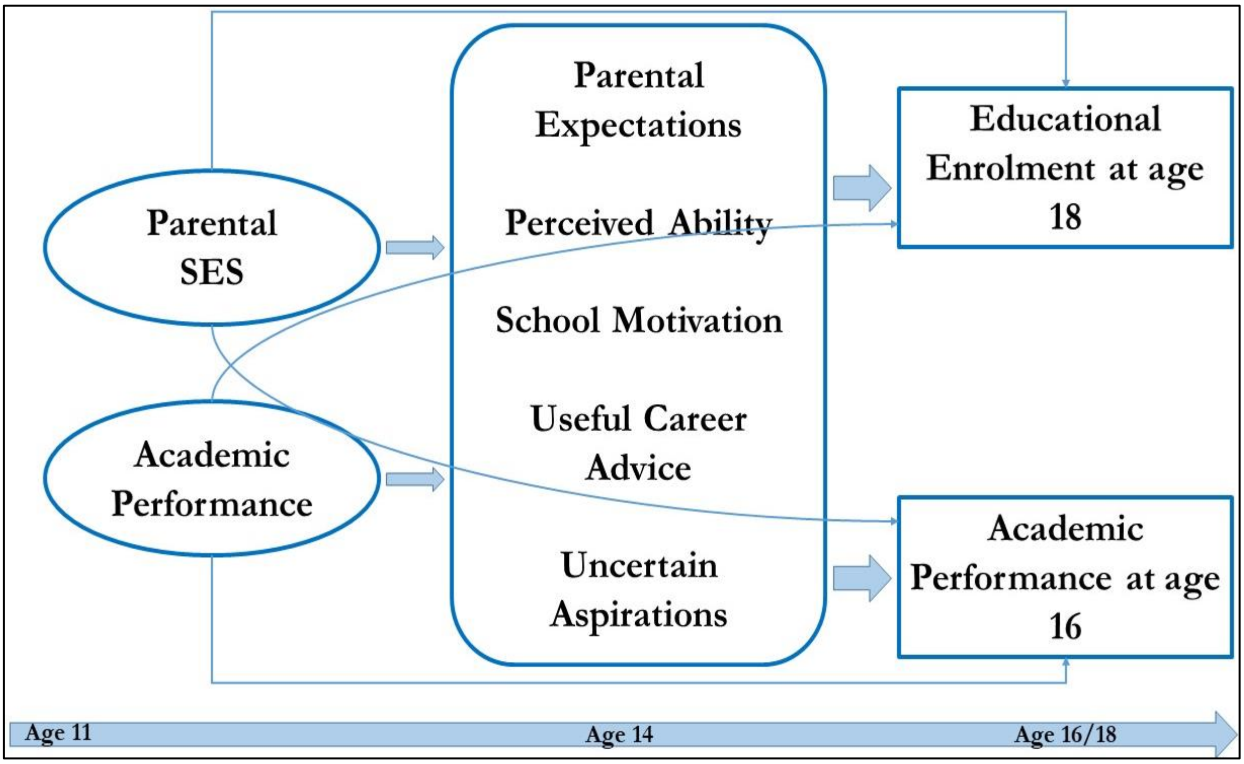


Figure 1-1 Taken from Gutman and Schoon (2012) pg. 3. It shows a developmental-contextual model of career development: focus on uncertain career aspirations.

This model (Figure 1-1) captures a timeline, which derives from life-span development theories, and contextualises perspectives discussed Vondracek, Lerner, and Schulenberg (1986) in their developmental-contextual model of career development. Schoon and Parsons (2002) explain how this model above accounts for the change and development of an individual in a changing context. Here a child will transition from primary (5-11 years old) to secondary (11-16 year old) education, often involving a change of school or setting. Learners will experience different teachers who have differing styles of instruction and may be exposed to different formal and informal educational experiences; thus, this model may still be relevant despite these changes in settings.

1.4 RESEARCH AIMS AND OVERVIEW

This doctoral research study explores how informal science educational activity can complement the formal instruction of science in school. Here the informal activity is any science outreach programme, which may take place in or out of school premises, aiming to engage and excite pupils to promote choosing science beyond the post compulsory age of schooling (Gall, Vollbercht and Tobais, 2020). Hence, it is an activity which goes beyond the prescribed science curriculum and often uses resources (both physical and people) that are not often involved in a 'regular science lesson'. Science outreach programmes take place globally and quite often focus on underrepresented demographics within STEM, such as those of a lower SES or ethnic minority groups (APPG, 2020). These activities are often part of widening participation (WP) activities offered by universities (Banerjee, 2017); however, the financial implications to both providing and attending these activities can be a limiting factor for engagement.

1.4.1 VIEWING THE IMPACT OF THESE PROGRAMMES VIA A DIFFERENT LENS.

When researching the impact of such outreach programmes, it is often student feedback or enrolment numbers that are generated and analysed (Alexander et al, 2011; Shanahan et al, 2011; Shaw et al, 2010). Thus, it is difficult to measure the impact of a particular intervention in science using this data. Falk and Needham (2011) describe how science understanding derives from a complex network of experiences that can change over time. Whilst collecting information from the learners is informative and valuable for future activities, the longevity of the programme's impact may be better informed by the teachers' perceptions over time; the evidence of which is far more limited in the literature. This is despite the strong suggestions that teachers and their assessment of an individual, can have an indirect impact on a student's own self-concept (Cridge and Cridge, 2015; Schoon et al, 2007; Alexander et al, 2011). One study (Osborne et al, 2003) which confirmed these ideas reviewed a plethora of research which investigated student's attitudes and interest in school science. Osborne et al (2003) concluded that a key factor for students' interest was the role of the teacher, suggesting that they considerably influence a student's attitude and persistence within the subject. Whilst these results do confirm the importance of the teacher in relation to a child's ideas regarding science, Osborne et al (2003) were conscious of how little research had been conducted, regarding how students viewed their own teachers and how it could influence them. However, subsequent research by both Schoon et al (2007) and Cridge and Cridge (2015) suggests that not only can the mannerisms and chosen instruction of individual teachers help to enthuse and maintain interest within the subject, a teacher, can also foster self-belief and facilitate subject-specific achievement within a student.

Therefore, teachers are perfectly positioned to have a deep understanding of how students respond to science outreach activities, and as gatekeepers to these activities, their perceptions are informed by experiences, and thus meaningful. This again highlights the pivotal role teachers' play in an individual's motivation in a particular subject, resonating with Bourdieu's (1977) concept of 'habitus'. A person's 'habitus' describes how an individuals' own core values, education, dispositions and beliefs can influence how they communicate with their students (Bourdieu, 1977). The teacher themselves' may in fact, present unconscious behaviour and expectations upon the child. This reflects the findings from Schoon et al (2007), that teacher evaluations (of the individual) are significant predictors in shaping occupational careers, and that this influences the child more than their family background.

The success of outreach activities is difficult to determine due to the social complexity of schools and the variety of science outreach activities offered. This research study investigates teachers' perceptions of outreach activities, including their views on how these outreach programmes could be improved to ensure a higher degree of impact. Therefore, the views of teachers have informed the development of the proposed outreach model. This was then further supported by wider literature, which reported the experiences of science outreach within the global context. Both these processes have contributed to generating a framework that will allow the researcher to offer recommendations of how to improve the effectiveness of science outreach programmes internationally. It is anticipated that if these outreach practices become more effective, teachers will want to engage with an increased number of these programmes, which are essentially designed to have an impact upon learner's attitudes and choices in science. Within this research study, there is a particular focus upon how science outreach programmes engage students from lower socio-economic backgrounds; therefore, a subsequent model is explored, focusing upon the most important features of the proposed initial 'optimum' model, to engage this demography of learners. The discussion regarding science outreach programmes, often focuses upon science in England due to the sample of the participants; but as science outreach is a global enterprise, this research study adopts global perspectives where appropriate as it is conceptualised as a tool that can inform science outreach practices internationally.

1.4.2 The importance of this research

The success of outreach activities is difficult to determine due to the social complexity of schools and the variety of science outreach activities offered (Banerjee, 2017, Gall et al, 2020). This research study investigates teachers' perceptions of outreach activities, including their views on how these outreach programmes could be improved to ensure a higher degree of impact. These experiences and views are captured within the developments of the proposed outreach model, along with a range of literature that will inform and support aspects of the design. It is anticipated that if these outreach practices become more effective, teachers will want to engage with an increased number of these programmes, which will further expose learners to a wider range of opportunities in science which can impact upon their attitudes (Archer et al, 2013). There is also a particular focus upon how science outreach programmes engage students from lower socio-economic backgrounds; therefore, a subsequent model is explored, focusing upon the most important features of the proposed initial 'optimum' model, to engage this demography of learners. This particular focus is important when considering the general demographics of those who work within the field of STEM and considering how to further diversify this (APPG, 2020).

Whilst the voice from the participants within this study will provide the skeleton for the design of this model, the literature from across the globe will further contextualise these findings so that the model itself can support similar international initiatives. This is an important aspect of this research project, as there is a wide range of research published internationally regarding science outreach programmes (see section 2.4 for examples of these) and many try to engage under-represented groups within their science fields (De Mulder et al., 2014; Erol, Buyuk and Tanik Onal, 2016; Goodman, 2002; James et al, 2006; Oshima et al., 2004). Additionally, two outreach models/frameworks proposed by Jeffers et al (2004) and Cridge and Cridge (2015) that shaped the initial proposal of this research, are based upon data from the United States of America and Australia. Therefore, using this wider literature to support the development of the proposed outreach model ensures there is a firm rationale for each aspect of its design. In addition, using age range of the learners rather than using country bound terminology (such as key stages in England), will allow the model to be utilised globally. Thus, this research study adopts a worldwide perspectives where appropriate, as it intended to be utilised as a tool/framework that can inform science outreach practices internationally.

The originality of this research centres upon its aims to utilise the teachers' viewpoints of these outreach programmes to suggest what content outreach programmes should include, and to ensure the model supports science outreach activities across the age ranges of 3-19. This model will also be informed by previous models that suggest structures for STEM based outreach programmes for example; Jeffers et al's (2004) framework for STEM outreach focuses upon common criteria found in outreach, and Cridge and Cridge (2015, p.40) suggest the ages that these programmes should "spark, sustain and convert" different learners. This will therefore, aim to provide age appropriate activities that facilitators of outreach programmes can deliver to support learners.

Within the models discussed above, teachers (Jeffers et al, 2004) and parents (Cridge and Cridge, 2015) were specified as stakeholders. Thereby, having multiple stakeholders included in the design of the model provides a unique angle to the study as the proposed model would support learners and both parents and teachers. This aspect is important to the researcher in particular as it is believed that choices made about science and future careers need to be viewed more holistically, as no goal/choice/motivational modal is insular (see section 2.1.2). Science outreach programmes have a degree of flexibility to their design, and unlike prescribed curriculums such as 'The National Curriculum' in England (DfE, 2013), they can cover more relatable and contextualised topics that may not fit within the statutory content but ignite interest in learners. This research is also important to the researcher in the context of narrowing opportunity gaps (Morgan et al, 2016) and building an individual's science capital (DeWitt and Archer, 2017), in the hope that this will help to provide even more positive science experiences for young people.

1.5 PRESENTING THE RESEARCH QUESTIONS

An initial non-committal literature review, which is described by Urquhart and Frenández (2006) as the process in which the researcher scans the literature to develop theoretical sensitivity, was conducted. In doing so, it allowed the researcher to be able to deduce the research problem and consider which methods may be used to solve the research aims. Thus, following this exercise the general objectives for this research study were formulated, which influenced the development of specific research questions; these are presented in Table 1-1.

Table 1-1 Research objectives and questions

Research Objective	Research question	How the question will be answered	Where will it be answered?
Explain how science choices can be influenced by home and school.	How can Parents, teachers and outreach programmes 'shape' a child's choice regarding science?	Review literature in the context of the role of teachers in schools, home-life and outreach work and their ability to encourage individuals to enter and persevere within the field of science Post-16.	Explicitly in Chapter 2 and 7, but also the discussion will be referred to throughout.
Explore teachers' perceptions of science outreach programmes.	What do teachers in the North-West of England think about science-based outreach programmes, especially in the context of learners' social demography?	Collate primary data from questionnaires, interviews and focus groups with teachers regarding their perceptions of science outreach programmes to inform a model of outreach and then subsequently a more streamlined version with a focus on learners of low SES.	Chapter 4 - 7
Suggest how science outreach programmes could be improved.	How can science outreach become a more effective intervention tool within the classroom?	Drawing on the analysis of primary and secondary data collected in this study, propose a model for science outreach work that will maximise potential for long-term impact for all students, and specifically those from a lower socio-economic background.	Introduced in Chapter 4 and discussed in Chapter 6 and Chapter 7

		Conduct focus groups to explore further teachers' understanding and interaction with science outreach programmes; use the feedback obtained regarding the proposed model to inform the delivery of science outreach activities.	Introduced in Chapter 5 and discussed in Chapter 6 and Chapter 7.

1.6 STRUCTURE OF THESIS

This thesis is organised into seven chapters and is summarised in Figure 1-2. A brief outline of the content of each chapter is presented below.

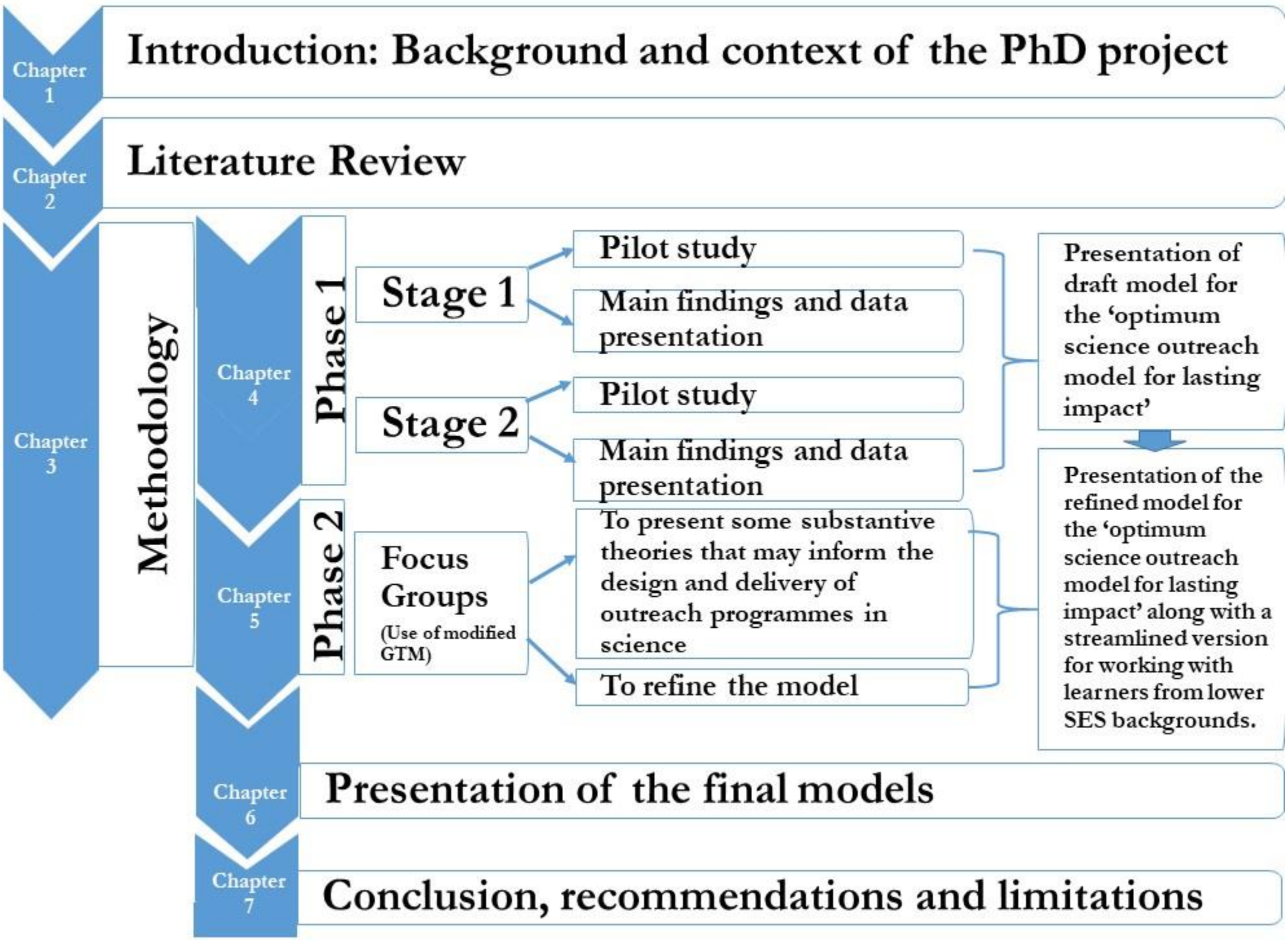


Figure 1-2 Structure of the thesis

Chapter 1 provides the background and context of both the researcher and the research project. It aims to; identify the overarching aims of the project, the design and structure of the PhD and how this research will provide a unique contribution to the field. Chapter 2 presents a body of literature that links to the key themes of home life and science, the role of the teacher, and science outreach programmes. Each theme is discussed and draws upon prior studies and global examples to contextualise and link the themes. This chapter also considers the challenges of the delivery and design of science outreach programmes, which is an important starting point in establishing the research aims and objectives.

Chapter 3 outlines the approach of the researcher and the methodology adopted to obtain the data. A clear outline is provided of the procedure and design of the research activities for both Phases of research for the PhD study, along with a clear justification for how reliable these processes will be. There is also a description of how results from each Phase will be analysed and the ethical considerations for the study.

With regards to the findings, Chapter 4 presents the data and findings from Phase One of the doctoral study, which culminates in a proposed 'optimum model' for science outreach programmes. It includes results from pilot studies and how these informed the 'main data collection timeframe'. Phase One uses quantitative and qualitative data to present teachers' general views and understanding of science outreach programmes. These, along with the literature explored in Chapter 2, are used to design the initial proposed 'optimum' outreach model. This is explained and justified in the final sections of this chapter which concludes with suggestions to be considered in the next Phase of the research study. Phase Two of the research study, is discussed in Chapter 5 and presents substantive theories regarding science outreach and depicts how the model was refined from Phase One of the study. As this Phase uses modified principles of constructivist Grounded Theory (GT) (Charmaz, 2014), this is explored and justified within this chapter, resulting in the presentation of substantive theories which derive from focus-group data.

The resultant models (including the SES related model) are presented in Chapter 6 The first model is the 'optimum science outreach model for sustained impact' and it is accompanied by a discussion of how its design is fit for purpose. Also, in Chapter 6, the 'Optimum science outreach model for engaging learners from a lower socio-economic background' is presented, accompanied by a clear rationale. Thus, this chapter's discussion centres on the use of both models to address challenges presented in Chapter 2.

Chapter 7 provides conclusions from this doctoral study by reviewing each research question as outlined in Table 1-1 and provides key recommendations to policymakers, outreach providers and schools, and suggestions for further areas of research within the field. There is also a critique of the research project itself and how the limitations may have affected the results presented.

CHAPTER 2: LITERATURE REVIEW

This research aims to explore how science outreach programmes may impact on the choices and perceptions a child may have about science. To be able to explore these themes it was crucial to understand the role of home, parents, schools and teachers in relation to science, and theories linked to motivation and choices. It was also important to understand science outreach programmes themselves and specific examples of these, including their design and success, as this would assist in devising the proposed model. Therefore, this chapter explores a range of literature which is presented in a range of themes and sections.

Whilst a systematic review provides many benefits when reviewing literature within a certain field, it was felt that in this instance that the rigidity and narrow focus may not allow for a comprehensive coverage of the range of outreach initiatives across the globe (Collins and Fraser, 2005). This was in part due to the wide inclusion criteria that was necessary for exploring themes linked to each research question. For example, science outreach may be categorised within a particular discipline of science e.g. biology, chemistry or physics and science may also be encompassed under the STEM or STEAM umbrella. Also, as the focus is upon outreach, this can focus on wider themes such as 'choices', 'influences and 'engagement'.

Therefore, the complexity of exploring these empirical papers required the inclusion criteria to be broad and open in order to develop a thorough understanding of current research knowledge and understanding regarding science outreach programmes. Evidence was included based on the assessment of the research as to whether it could provide insight into what science outreach programmes might entail, the general purpose and evaluation of the benefits of these programmes and reasons stakeholders may engage. Literature that was excluded was those which were solely focused on outreach as a recruitment tool from the perspective of HEIs, and those which linked to targeting undergraduate students. However, as the inclusion criteria was vast, few research papers directly linked to the field were deemed to be irrelevant, due to the purpose of gaining an holistic overview of science outreach practices at the time the literature review was undertaken.

Thus, a narrative review of the literature covering a range of topics and themes was conducted. This allowed the researcher to utilise broader terms that are used in this extensive, and varied field. For example, "science outreach", "STEM outreach", "STEM clubs" and "science trips and talks" could all encompass the topic of outreach. Additionally, the themes of this research also look at specific experiences related to teachers" and learners from a "lower socio-economic background," which also has a plethora of terms to describe this group of students. A range of databases were explored such as; Science Direct, PubMed, SpringerLink and Taylor and Francis, along with the 'Discover' tool on LJMU Library database and Google Scholar. The date range of these searches were vast and not particularly selective because of the nature and the variety of topics then needed to be included within this chapter.

It is also to be noted that the literature from this chapter has informed the creation of the questionnaire used within Phase One of this study, and Chapter 2 frames the subsequent steps taken within this PhD research study. Therefore, at times discussions are limited in terms of the available literature, at the time of writing, but it was felt that it would be more suitable to add further, and more recent literature within Chapters 4-7 to coincide and inform the creation of the model(s).

2.1 UNDERPINNING THEORIES

Although outreach programmes in science do often aim to assist with the formal learning process, one of the main aims of these programmes in school is to shape future choices when it comes to science (Dent et al, 2014). Quite often the route to a career in the sciences involves attending a Higher Education Institute (HEI) to undertake further study within science, and to encourage those from under-represented demographics (such as those learners of a lower SES), HEIs often utilise outreach programmes as part of their widening participation (WP) activities (Dent et al, 2013). HEFCE (2010 p.29) highlight how these WP programmes are "any activity that involves raising aspirations and attainment and encouraging students from under-represented groups to apply to higher education". Therefore, whilst there needs to be an appreciation for how children learn, the theories that are at the root of this research focus on what can influence choices when it comes to staying in science.

2.1.1 LEARNING SCIENCE

Skinner (1957) and Pavlov (1897/1902) support behaviourist theories of learning in which knowledge is the objective. Learning takes place when there are regulated stimuli and responses, or quite simply input (knowledge) and output (understanding) (Daniels et al, 2009). These theories support the transmission model of learning, which is often associated with passive activities and leaves no room for an individual to not see or understand what information is being passed on. Murphy et al (2009) provide a classroom example of a teacher leading an activity about observations of dissolving sugar and salt. The teacher presented the phenomenon and emphasised what he observed to be of importance in developing a full understanding around the topic. It is clear that the outcome of the activity is to be able to provide evidence that pupils can convey what the teacher has shown them. In contrast to this process Vygotsky (1987) explores the ideas of the two stages a person goes through when learning; one involving the primary experience of negotiating the meaning in which the information was received and secondly, processing this on a personal basis to allow an individual understanding (Murphy, 2011). A passive model of learning does not allow this second stage to take place whereas an active model of learning does, as individuals are active constructors of this meaning.

Greenfield (2004) describes how the brain is the organ responsible for how we learn. From just 4 weeks after conception, a primitive organ that is to become a brain begins to form and research that supports intelligence as a genetic trait identifies that here, in the womb, neurones are making connections that could account for up to 20% of a person's IQ. However, Greenfield (2004) also argued from the point of birth, no individual experiences the same sequence of events and therefore the mind of a person will be different and unique. This difference in experiences therefore have a factor in the learning process and for the child these disparities begin during the early years at home, continuing into school. Vygotsky (1987) and Hobson (1998) highlight that this personal dialogue to process one's own understanding means that learning is an individual process in which ideas are to be formed. This personal venture is strengthened by social factors in which collaborative learning, along with guidance from teachers and experts, allow ideas to be constructed (Murphy, 2004). These theories have now been adopted by science educators in the hope that, if better understood, the quality of teaching and learning in schools can be improved.

Piaget's (1936) insight into cognitive development is often referred to as the foundation of constructivism (Phillips, 1995). He simply stated that knowledge cannot be formed from simple observations but that activities need to follow to secure learning. However, Piaget linked the formation of this knowledge with cognitive development and believed that the 'cogs', or developed connections, must be put in motion before specific levels of learning could take place (Hobson, 1998). Vygotsky (1978) opposed these ideals of having fixed developmental stages of learning. He agreed to some extent that development plays its part but is not a limiting factor in what can be learnt. Vygotsky (1978) was also prominent in explaining that learning comes about from social interactions which led to the notion of social constructivism.

Wood, Bruner and Ross (1976) shared views that teachers should focus on developing something Vygotsky (1978) called the zone of proximal development (ZPD), by providing activities and opportunities in which children can acquire competence in shaping their own learning (Hobson, 1998). This idea suggests that if learners undertake problem-solving activities with the guidance of an informed adult or collaborate with competent peers then that new learning becomes internalised, and the individual's ZPD grows (Cheyne & Taruilli, 2005). This is supported by research conducted by Greenfield (2010) arguing that 'neuronal plasticity' is key to learning and development as experiences and our environment are what personalises our brain to create the idea of 'mind'. Experiences and environments are what Vygotsky discusses as these social constructs which assist learning. Therefore, this research project considers how, if outreach programmes are designed with this hands-on approach in mind then maybe it could further enhance an individual's learning experience in science.

Thus, understanding how children may learn science and the different ways individuals learn is important in the context of all research questions. This is important because learner's can receive a variety of science instruction and these experiences can lead to certain beliefs regarding the nature of science itself and their perceived ability of science (Grabau and Ma, 2017; Hampden-Thompson and Bennett, 2013; Jen et al, 2013). Additionally, teachers have their own beliefs about what is an appropriate way to teach science and this may have an impact on what they believe effective science outreach looks like (Shirazi, 2017). Finally, as the third research question wishes to explore how science outreach may become a more effective intervention tool within the classroom, it is important that those who design and facilitate these programmes are aware of different approaches to science instruction. This is especially important as the instruction may further shape the possibility and desirability of science (Archer et al, 2020). Thus, this aligns with the aims of this research to be able to consider how the design of these programmes could further enhance individual's learning experiences and beliefs about science.

2.1.2 Choices in Science

Lavigne et al, (2007) discuss that motivation in science derives from pupils' own perceptions of themselves as autonomous learners and their competence in a subject. For example, Marchand and Taasoobshirazi (2013) discuss concerns regarding the lack of girls choosing to study physics and suggest that it could be linked to the teaching of the subject itself and the ability of the learner to relate to the content within the course. Lavigne et al (2007) describes how students will engage with content and activities, intrinsically or extrinsically depending on whether they can see that there is a purpose for themselves or their surroundings. Smith et al (2015) explain this as the formation of social identities from people's own knowledge of their membership within a social group; such as demographic or biological sex. Steele and Aronson (1995) link these findings to something known as 'stereotype threat' which is described how individuals may feel threatened when their behaviours may 'confirm' an associated stereotype. This can cause reduced efforts as if a person feels that they are in the minority, or their role is to be the 'token' demographic within the group they may already possess concerns about fulfilling the gender stereotype which already exists. It could also lead to disengagement as an individual may feel that stereotypically they are not seen as being good at something, such as girls and football, then they may disengage from a particular field. This idea of 'stereotype threat' can change a person's life goals based on how they feel and the stereotype in which they are portrayed (Steel and Aronson, 1995).

Harlen (2008) suggests that perceptions of a subject may arise at a very early age as a child begins to explore and engage with the world around them. Therefore, it could be argued that ideas about science, whether formally taught or not, are formed long before choosing which A-level to take. These notions are supported by the findings of Renninger (1992) who studied interests in young children. It was identified that age 4 is where children exhibit a sustained interest as they are able to demonstrate attention and memory when it comes to an involvement in a particular activity. These sustained interests are associated with increased persistence, positive engagement and choosing to engage in a particular activity compared to others, which is important when it comes to cognitive development as they will affect what stimuli are chosen (Renninger, 1992). Leibham et al (2013) describe how these early interests that may have an impact on future learning and that as individuals develop their understanding of their attributes, abilities and values, children begin to gain self-concept of their characteristics.

Marsh et al (1991) then highlight how self-concepts of children become more realistic and multidimensional at around the age of 8, this coincides with the child moving into a more structured classroom which means the individual has less freedom to self-select and play. Chafel (2003) suggests that children constructing their concept of self are very much influenced through everyday interactions and play. Therefore, understanding interests of young children is important as they "may be related to the development and enhancement of their self-concepts, though an exact model of the relations, particularly for children, is not currently available in the literature." (Leibham et al, 2013 p.577).

When considering these discussions regarding age it suggests that regardless of whether the teacher can provide this motivation and pleasure in school, children could already be forming their own preconceptions of what science is, at home. Leiberham et al (2013) acknowledge that interests do not just develop as a stand-alone process, but it is the microsystems in which children are part that have an influence too. This again places parents at home and teachers at school in an influential role. Rodd et al's (2013) study looked at the idea of 'unconscious forces' which draws on research from Sigmund Freud. Frost (2006 in Rodd et al, 2013) explains these forces as emotions or motivations that influence behaviour that you yourself are perhaps, not aware of which may derive from a variety of social settings. Therefore, these 'forces' could influence a young person's decision when it comes to considering whether to continue studying science or not. These 'forces' were evidence in the interviews conducted by Rodd et al (2013) who found that some reasons for choosing to study this subject linked to ideas about 'enjoyment', but another underlying factor linked to individuals having an adult 'role model' as a motivational factor to participate in science. These discussions suggest how science outreach programmes may also be able to influence choices in science. If the teaching aspect of the activity or the person(s) who deliver the activity are engaging, then this could have a positive impact on a child's experience of science.

In general, when deliberating how choices may form in science, the level of an individual's science capital can influence whether a learner may regard themselves as 'science-y,' which in turn, may have an impact on an individuals' future choice to engage in science (Godec, King and Archer, 2017, p.9). Science capital is a concept which is underpinned by Bourdieu's 'capital' (Bourdieu, 1977) and further formulated from a 10 year longitudinal research project entitled the 'ASIPRES 'programme. This study wished to explore how young people's (aged 10-19) science and career aspirations may be derived (Archer et al, 2013; Archer et al, 2020). It is explained by Godec, King and Archer (2017) that the key dimensions of raising science capital are focusing upon: scientific literacy; science related attitudes, values and dispositions; knowledge of the utility of science; science media consumption; participating in science events outside of the school context; a family's science knowledge, skills and qualifications; knowing people in science related positions; talking about science in everyday life. Thus, recognising the importance of developing one's science capital, with the view of raising individual's aspirations towards science is considered important for increasing and diversifying the STEM workforce (Archer et al, 2020). Therefore, whilst this Doctoral Study is not focused on science capital, it is important to recognise this concept as it aligns with the first research question (see section 1.5) and several of the key dimensions of science capital.

Below are some theories that outline motivation and career choices in education that are important when it comes to considering the content and design of outreach programmes in science. It also highlights why the developmental-contextual model of career development (Gutman and Schoon, 2012) was deemed as the most appropriate conceptual framework for this research project but acknowledges how other theories may also be important when considering the impact of engaging with science outreach programmes. Thus, by exploring factors that might motivate children in science will again assist with responding to the first and third research questions proposed in section 1.5, as these motivational models and the chosen conceptual framework underpin how choices in science could be made. It also helps to visualise how the addition of an external factor such as 'science outreach' could impact upon motivation in science.

2.1.2.1 Expectancy-value theory

Atkinson (1950) explored ideas about the achievement motivation of individuals, and it was three decades later, where Eccles (1983) linked these ideas to education. Partridge et al. (2008) highlight parents at the core of this theory as providing achievement experiences for their children: However, parents will perform these tasks based on their own belief systems and expectancies, values and gender-related beliefs which means that this 'vicious circle' approach to beliefs is heavily related to family and parental socialisation practices. In terms of education, the expectancy-value theory links attainment and achievement-related choices; these are determined by expectancies for success and subjective task values (Partridge et al, 2008). Eccles et al (1983) first proposed an expectancy-value model in the context of the mathematics; the model provides the relationship between expectancies, values and achievement, and the latter is directly influenced by the others. It is explained, however, that beliefs influence these expectancies and values about ability, self-schema and affective memories which are in turn affected by an individuals' perception of their experiences and socialisation influences (Wigfield and Eccles, 2000). This brings the idea back to how parents and cultural factors may have an impact on task-specific beliefs.

This theory thus describes how an individual will choose, persist and succeed in a career or field of study if they believe they will do well. Smith et al (2015) link this theory to the negative impact of stereotype threat (see the previous section) as an individual may perceive their 'value' to be low. Therefore, this could affect their performance within a subject. It is essential to develop an awareness of the ideas of an individual's expectancies, and values of a particular subject as science outreach programmes aim to provide positive experiences that may have some influence on these. However, this research does not wish to place a central focus on achievement in science as a factor for remaining in the field.

2.1.2.2 Self Determination Theory

Self-determination Theory (SDT) is another motivational theory. It acknowledges the innate psychological needs, including competencies, readiness and autonomy, as the essentials to facilitating growth and constructive social development (Deci and Ryan, 2000). Deci and Ryan (2000) highlight how motivation is not just a singular unit, but that it is important to distinguish between autonomous motivation and controlled motivation (Deci and Ryan, 2015). Autonomous motivation allows an individual to make sense of what they are doing and that they are choosing to do it because of it being interesting or enjoyable, making it a positive experience and encompassing a sense of choice. Ryan and Deci (2000, p.70) outline this as intrinsic motivation whereby they describe how "no single phenomenon reflects the positive potential of human nature as much as intrinsic motivation, the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities to explore and to learn." It highlights how curiosity and inquiry allow freedom for the individual to learn and grow. However, being able to maintain this type of motivation requires a supportive environment. This draws upon the discussion of environmental factors and how they may hinder or have a detrimental impact on self-motivation.

Ryan and Deci (2000) also question how as a person gets older and social pressures reduce the opportunities to be free and intrinsically motivated, then another type of motivation must drive a person forward. The contrast to this type of motivation is known to be extrinsic, whereby activities are performed in order to attain additional outcomes. Ryan and Deci (2015, p.486) suggest that this controlled motivation tends to leave the individual with feelings of "pressure and compulsion, rather than concurrence and choice." However, SDT acknowledges that these extrinsic motivations also contain an element of autonomy, but this can vary, for example; a child may complete homework as they see its worth in terms of the career in which they wish to pursue, as opposed to doing so because their parents made (controlled) them to do so.

In terms of motivation in science, SDT indicates the importance of autonomy and Lavigne et al (2007) highlight how teachers have a supportive role to play in fostering this within the science classes. It is concluded by Lavigne et al (2007, p.352) that the "more self-determined their motivation towards science, the more likely it is that students will have the intention to pursue studies and eventually work in a scientific field". Therefore, as discussed as part of the SDT, the understanding of the different motivations that may lead to actions is hugely important in terms of persisting within the field. This research acknowledged SDT as having an important theoretical underpinning as it considers how environmental factors such as home and schools can impact motivation. This is hugely important when adding science outreach programmes as an additional environmental factor. However, the research aims of this project will not focus on motivation in science as the data is from teachers and not the children making SDT important, but not central to the study.

2.1.2.3 Achievement Goal Theory

Maehr and Zusho (2009) highlight how motivation is usually associated with what influences a person to begin, perform and persist concerning a task; however, goal theories often consider what gives a task a purpose or a meaning and the outcomes of these. In Achievement-Goal theory, there is a focus on why a person is trying to achieve a particular goal and not so much what they are achieving. For example, a student may want to achieve a top grade because they want to learn and master the material, or they may wish to get a top grade because they want to prove something to themselves or others that they are smarter. However, this does not necessarily mean that they have mastered the subject (Urdan and Maehr, 1995).

This relates to other motivational theories, but instead of a focus on self-efficacy beliefs, it centres more on motivation to achieve something and has become an increasingly more critical perspective when it comes to academic motivation (Kaplan and Maehr, 2007). Whilst, achievement goal theory is important to consider as part of the theoretical perspectives of this piece of research, the aims and objectives did not focus on the achievement of the students.

2.1.2.4 Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT) was developed by Lent, Brown and Hackett (1994) and it aims to explain aspects of career development. Its origins are derived from Bandura (1986) who looked at social cognitive theories that linked motivation and cognitive processes; the SCCT places these ideas in the context of how academic and career interests develop, how these choices are then made, and how success within these realms is obtained (Hackett, 2002). Therefore, the theory focuses upon self-efficacy beliefs, outcome expectation and goals that are all factors the previous motivational theories discussed. Whilst self-efficacy may change based on the task performed and are based on personal experiences and persuasions; outcome expectations consider the consequences of performing these different tasks. Personal goals relate to an individual's intentions to engage and achieve in an activity, and to some extent, these lead to an individual guiding their own behaviour (Hackett, 2002).

When considering the SCCT model of educational and vocational interests, it considers how these factors intertwine and can have an influence on choices made (Lent *et al.,* 1994). Hackett (2002) explains how the central core of this model is career-relevant activities that are curated as a child is exposed to school, home and communities. These activities will vary depending on these experiences, which will have an impact on self-efficacy and outcome expectations. As an individual is exposed to these activities, they will continue to develop skills in these areas; if these skills are seen positively, then it may link to increased interest within the particular field that may have an impact on future choices (see previous section 2.1.3). Until late adolescence, these interests may become interchangeable, which agrees with Renninger's (1992) ideas about why these interests are more fluid. SCCT highlights that if interests do change post-adolescence, then something has occurred to alter a person's self-efficacy beliefs and/or outcome expectations (Hackett, 2002).

The SCCT does discuss how interests may change over time and how schools, homes and communities are central to these experiences: However, these factors are not as explicit when compared to the developmental-contextual model of career development. Therefore, whilst this theory is important to understand when looking at the impact of science outreach as a tool to expose individuals to career-based activities, it is not the most appropriate especially as Barrera (2015) explains how outreach programmes aim to provide positive experiences throughout the transition between educational levels, which does place a focus on how the passage of time may have an impact on these experiences.

2.1.2.5 Developmental-contextual model of career development

The developmental-contextual approach to lifespan career development (Vondracek et al, 1986) serves as a stimulus to researchers and practitioners in career development who wish to gain further understanding of the developing person in a multitude of ever-changing contexts (Voldracek and Porfeli, 2008). It is visible that this theory centres on the idea of 'choice' and it is visible from the model itself (Figure 2-1) that motivation does have a vital role to play.

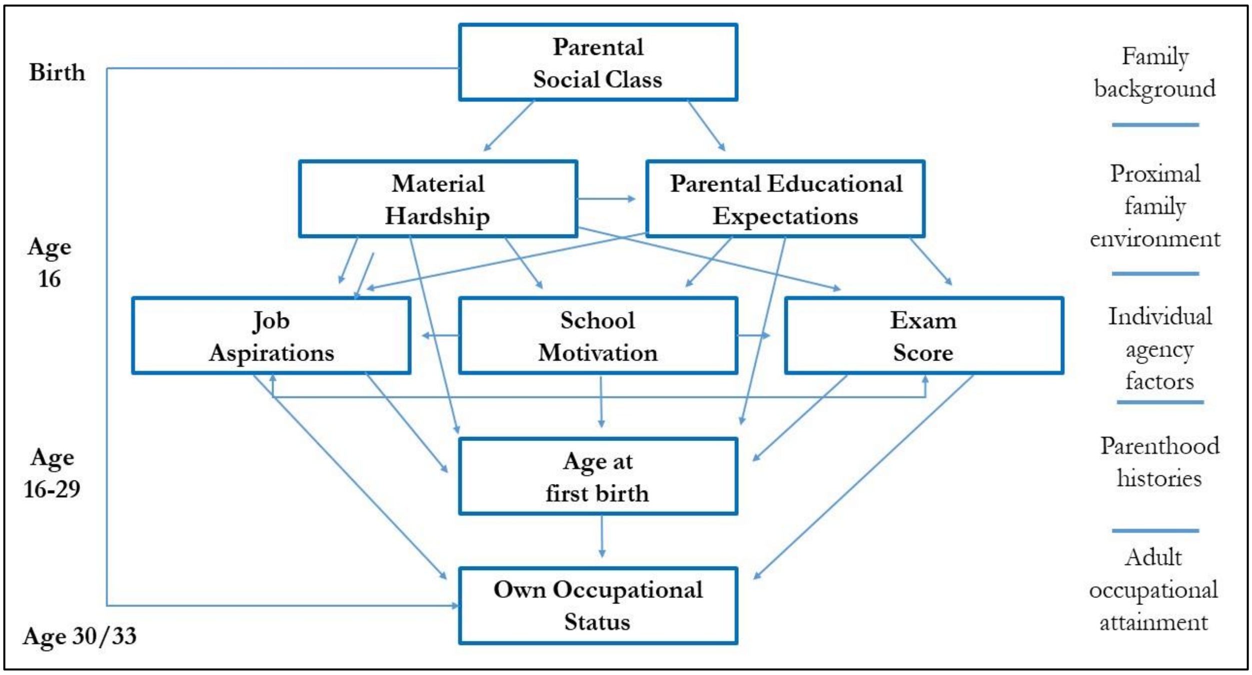


Figure 2-1 Development-Contextual Model of Career Development taken from Schoon, Martin and Ross (2007) p. 80

Super's (1980) 'Life-span, life-space approach' and Gottfredson's (1981) 'Developmental Theory of Occupational Aspirations', aim to understand career choices, but they focus on either the individual or the effects of personal factors. Schoon and Parsons (2002) explain how this 'developmental-contextual model of career development' framework stresses the mutual relationship between the individual and the context and therefore, no singular moment can be considered as the real 'mover' or change. It is explained how these contexts may have a direct impact on the proximal systems such as the social or material settings or an indirect impact on distal systems such as social class, parents' workplace or cultural norms. In the distal systems, the individual does not play an active role, but the contexts may have a role to play in terms of the individual. Thus, the journey through life is viewed as developmental processes extending over time which are shaped by complex interdependent relationships, including links to parents as well as individual agency processes (Gutman and Schoon, 2012).

Schoon and Polek (2011, p. 210) explain how adolescence is a "critical juncture in occupational development", and that teenage expectations are an important predictor for professional careers in adulthood. Vondracek et al (1986) suggest that socialisation processes and opportunities differ between families of different socio-economic status, which causes differences between teenage aspirations and transitions between childhood and adulthood. Put simply; it is believed that individuals from more affluent backgrounds have more educational opportunities and access to other resources when required (Schoon et al. 2007). This theory of a Developmental-Contextual model of career development takes into account; therefore, family and parental social class. This often means that individuals from poorer families and those who had lower prior achievements displayed uncertainty when it came to choices about their future career (Gutman and Schoon, 2012). Gutman and Schoon (2012) conducted a longitudinal study to investigate career pathways of a cohort of young people in England born in 1989/90 looking as to whether their uncertain career aspirations provided the link between socio-economic status (SES) and prior achievement to later outcomes in life. They were surprised to discover how young people actually performed better in terms of academic achievement and enrolling onto educational courses at 18, suggesting that having a period of time to 'explore' these options has a positive impact. Figure 1-1 (introduced in 1.3.2) focuses on how uncertain aspirations fits into the contextual development model of career development.

Therefore, the Developmental-contextual model of career development, even when a child does not know what choices they want to make, contains factors that are central to this study. It acknowledges motivation as having an indicator towards future choices, but it explicitly refers to context such as socio-economic background and how this context changes over time. Therefore, as this research wishes to collect data from teachers across different educational levels and design the model which guides outreach programmes based on children at different ages, this theory is most aligned to the research aims. It also provides a platform to be a tool to provide useful career advice and role models and opportunities that may 'close the gap' between individuals from higher and lower socio-economic backgrounds. Therefore, outreach programmes in science may be able to influence academic performance at 16 and educational enrolment at 18.

2.2 The influence of socio-economic status on an individual's choice about their educational future as a scientist in the UK.

The previous section highlights what may influence motivation of an individual and it is visible that an individual's home-life and socio-economic status (SES) may have an impact on this. This next section aims to explore further how and why these factors are intrinsic to future choices in the context of science. Social Mobility Commission (2017) depict how low income learners make less progress as they move through the educational system and that parental factors are influential in this problem. See et al (2012) share the world-wide concern that young people from disadvantaged backgrounds are less likely to follow high-status routes after compulsory education. These concerns were evidenced in England, as it was found that a school's percentage of disadvantaged pupils still has the most impact on school maths and science achievement and progression to A-level (CASE, 2018). These findings are also based on GCSE science and maths results from 2007-2012 from 300 schools in England and from the National Pupil Database (NPD) for the A-level results (Banerjee, 2015; Banerjee, 2017).

Greenfield (2010) describes; 'experiences' and 'senses' are formed from personal experiences and observations. However, it is found that members of a culture/society have similar ideas and views of the same situations, language is shared to describe these 'phenomena' and this shared language allows a uniformed understanding or quite simply common sense. Common sense develops as a child's language and experience become more complex which links to developments of learning new (and more advanced) concepts. In this instance, the first personal experiences for a child stem from their home-life which include interactions with family members and their community. Therefore, an individual who comes from a family who has a lower income may have very different experiences and conversations to their peers from a more affluent background.

2.2.1 Socioeconomic status and science

Gorard (2008) outlines that several developed countries, including the UK, have expressed concerns regarding the decline of post-16 participation of 'hard' sciences such as physical sciences and chemistry. It is also noted that those who apply for sciences (not just hard science) are more likely to do so if their profile shows a higher occupational class. It is therefore to be considered that that some social groupings appear to be excluded from the science profession (Anderhag et al, 2013). Tobin (2004, p.191) agrees that “home is also a factor that can either foster or inhibit the learning of science”. Socio-economic status (SES) or ‘home’ refers to a young person’s family background in terms of; occupations, educational qualifications and income, and considerations are also made in terms of sex, ethnicity, language, any disabilities and location. It is extremely important to consider participation in non-compulsory science, as the socio-economic gap of those choosing to study science does not derive from further education (for 16-19 year olds) but much earlier (Social Mobility Commission, 2017); most pupils would not apply for related courses at an HEIs if they were not studied at a foundation level (Gorard, 2008). These findings are what generated Gorard’s (2008) ideas about science being ‘a white middle class phenomenon’ as it is found that the SES of a learner has an impact on their decisions in choosing to study science, as earlier experiences and attainment in science that can directly impact on these decisions.

In terms of attainment in science, the biggest gap between groups of learners lies between those of free School meal (FSM) and non-FSM status (Gorard and See, 2009). Gorard (2012) outlines that free school meals are offered to those pupils who are from financially disadvantaged backgrounds and he explains that this is also a good indicator of SES. This information has been recorded since 1992 and there has been a clear aggregate between those obtaining FSM and attainment, particularly in science. For example, Educational Journal (2014) reports that white British children with a low SES spend fewer evenings per week completing homework and their attendance tends to be lower. All this may have an impact on attainment in school, which includes science. FSM data is widely used by the DfE to compare school performance as they link FSM to the background of pupils at the school. It is also useful for Higher Education Institutes (HEIs) who use this to direct their WP programmes to engage these disadvantaged learners (Gorard et al, 2019). However, Gorard et al (2019) express that using FSM as a contextual indicator should be treated with caution as they discuss how there will be children just above the FSM threshold that experience very similar levels of disadvantage.

Pupil premium (PP) was funding set up by the UK Government 2011 to help narrow the gap between attainment of FSM and non-FSM pupils and in 2017 the average primary school received £81,441 and secondary school received £167, 948 to assist with this (Education Endownment Foundation (EEF), 2018). Ofsted (2013) reported that there was a growing number of schools who were using this money to help raise attainment of poorer students but pointed out that many schools struggled to use it to make an impact.

The EEF (2018) agrees as they discuss in their report that no-matter the type of school there was still a noticeable attainment gap between these disadvantaged students and their non-disadvantaged peers. It was recommended that there was a tiered approach to the spending whereby there was a clear focus on improving teaching, providing more targeted support and then focus on wider strategies such as improving attendance (EEF, 2019). Despite these recommendations, schools are still able to choose how they use the use the PP funds which means that some schools are not using the money to encourage achievement of those who are FSM, but are deemed of high academic ability (Ofsted, 2013). This could mean pupils with the potential to study science are not being encouraged by the school, and if these individuals are on FSM it could mean there is no encouragement at home.

2.2.2 The context of 'home' and parents when it comes to learning in science

Science education begins as soon as the child can recognise features in which the world they live and communicate those around them; Vygotsky (1978) exemplifies this through the discussion of the dialectical relationship between the 'intramental' and 'intermental' planes. For example, a child's cultural development will firstly take place on an 'intermental' level which consists of many social interactions, these are then supported on a psychological plane and embedded into the mind on an 'intramental' level to making learning more autonomous (Murphy, 2011). This means that learning exists in the interactions outside of school and much of this will take place at home. Throughout school, pupils spend a large proportion of their time in this social setting and the importance of being aware of these links made about the planes of learning is summarised in Leach and Scott (2004 p.85) as they state that "Vygotsky's perspective on development and learning is that higher mental functioning in the individual derives from social life." Therefore, importance needs to be placed on fostering learning outside of school.

Domingos (1989) identified that those of a working-class background may find it harder to relate and contextualise the scientific ideas present in everyday activities compared to that of formal settings making understanding of scientific concepts more difficult to manage and less stimulating than those of middle-class backgrounds. Gorard (2008) describes that for a person of low SES, even if they don't have a specific religion or belief, science practices do not relate to 'people like us'. This detachment may mean learners simply 'go through the motions of science' at school and do not seek the 'secure understanding' that will help them when being formally assessed. In addition to providing a context, there are other factors that can have adverse effects on choices and performances of an individual from a low-income family. Cooper and Stewart (2013) reviewed 34 studies from around the world and conclude how income does matter, as it can cause stress and anxiety. This may have an impact on maternal mental health and parenting behaviour, or it can have an impact on the parent's abilities to invest in goods to further child development.

Fleer and Rillero (2008) suggest that qualifications of parents can play a factor in a child's preference towards a subject or career as this also links to the SES of their home environment. There is an assumption that parents with higher levels of qualifications or those who work in a specific field may have a higher income and jobs in STEM often come under this remit. Gorard and See (2009) link these factors to conclude that parents from lower social classes may be less willing (or able) to supervise schoolwork and activities at home due to their own lack of confidence. This is supported by Harris & Goodall (2006 in Gorard and See, 2009 p.115) who find "that higher the social class, the higher the parental involvement".

Though SES is seen to have an impact on attainment in all subjects (Smith, 2010; Gorard, 2008) it is suggested that participation in science is increased by parental encouragement (Gorard and See, 2009; Social Mobility Commission, 2017). The barrier could even be as simple as the fact that there is a lack of parental advice when it comes to making decisions about further study of science subjects or they simply have a negative impact on attitude and enthusiasm in science. Fleer and Rillero (1999) review research regarding the impact of family involvement in science attainment, as they describe that these studies are difficult due to the nature of collating the evidence and controlling the study. However, they do highlight how complex parent involvement can actually be and that there is a direct link between increasing positive attitudes in science and parental involvement in activities such as helping with homework, reading and discussions about science.

In a study conducted by Capron and Duyme (1989 in Gorard and See, 2009) the idea of innate and inherited ability was reviewed by looking at an individuals' SES. They studied children born to academic and non-academic parents and what happened when they were placed in different SES homes. It was found that those individuals who were born to any type of parents, but who were adopted to high SES parents did score higher in tests carried out. This example study aimed to understand the links between attainment and home life. Therefore, the results may be explained by Greenfield (2010) who considers that a huge amount of what we learn comes from the culture we grow up in. She argues that connections in the brain, commonly referred to as learning and understanding, are similar to genes and can be switched on or off depending on our own personal experiences. These past experiences can then shape how an individual perceives and views new information (Greenfield, 2010). This then could be difficult for schools as they need to teach the prescribed National Curriculum which outlines what scientific topics to learn about (Bruner, 2004). To fully understand and appreciate science, learners often draw on localised or private experiences, and depending on an individual's home-life, this may not match the requirements of the curriculum (Hughes, 2004).

2.2.3 Accessing higher education

In England and Wales, as well as drawing upon educational research, educational policies derive from the government's values and visions. For example, Skelton and Gorard (2011) exemplifies how the change in UK Government after 2010 saw a change in funding and resources available in this sector. A major impact for potential students was the cost to them to attend a HEI which increased significantly; in England and Wales the average cost is around £9250, in Northern Ireland £4160 and in Scotland it is around £1820 (The Complete University Guide, 2020). Kentish (2017) compared these fees in England to other countries and found them to be up to 25 times higher than for their French peers and even higher than in the US where the average student pays $9,410 (£7,518) per annum. Although there are student loans available to assist with tuition costs and maintenance loans for living costs these only cover frugal living and are considered prohibitive without additional income. This could leave an individual from the most disadvantaged backgrounds having loans of about £54, 582 (living away from home outside of London for a 3-year programme) (Student Finance England, 2020). This rise in tuition costs fuel concerns about reduced applications from students of a lower SES, regardless of whether they chose to study the sciences or otherwise (Banerjee, 2018).

Gorard and See (2009) found that most pupils do recognise science as an important factor in their everyday lives, but when considering subjects that will help them to find a job, it is not seen as important as English and Maths. They also state that "studies have shown pupils to view science as a difficult subject." (Gorard and See, 2009 P.107). This is shown in studies about FSM and achievement, where even the FSM attainment gap is much smaller in science compared to English or History for example. This links to findings about cost of higher education (HE) as Cridge and Cridge (2015) and Gorard and See (2008) describe science as a "financially risky career path". This means that, as it is perceived as a 'hard' subject, it may be more difficult to receive a 'good' A-level grade and they are putting themselves 'at risk' of receiving a poor qualification.

In addition to this, due to finances, a child may seek part-time employment and this could then mean that it is difficult to balance work and studies (Gorard and See, 2008). To increase the participation in science it would seem logical to try to remove these barriers, and measures such as means-tested bursaries are used to alleviate these stresses (Gorard and See, 2009). Therefore, further considerations need to be made to the learning as to why this group is so underrepresented in those going to study sciences at university (Forsyth & Furlong, 2003 in Gorard and See, 2009). Gorard et al, (2019) and Banerjee (2018) have called for HEIs to continue to widen participation by using more contextual indicators that may outline social disadvantage to be able to offer contextualised admissions to increase these under-represented groups at a wider range of HEIs.

2.3 THE INFLUENCE OF THE SCHOOL SCIENCE TEACHER

Osbourne et al (2003) reviewed a vast amount of research that investigated students' attitudes and interest in school science. They conclude that a key factor in a pupil's interest was the teacher, suggesting that they have a major role to play in developing a student's attitude and persistence within the subject. Hattie (2012) agrees, describing how teachers are a crucial factor in driving academic achievement. However, Osbourne et al (2003) described how little had been considered to establish how students viewed their own teachers and how it could affect them. For example, although the teacher may provide scaffolding to support learning in science, Murphy (2011b) describes that a person's place within a peer group could affect the position and responses given. This means that a teacher not only has to guide learning but do this in a manner that makes a learner feel confident to share ideas. Whether behaviourist or constructivist attitudes are adopted to learning, Guile and Young (1998) imply that individuals themselves hold the key and have responsibility for their own learning. Thus, a teacher has to be able to nurture a class of individuals and their personalised learning experience whilst also delivering the prescribed curriculum and meeting exam target grades. These next sections aim to outline how a teachers' own beliefs and experiences may vary and therefore, how these could impact on a child's perception of science.

2.3.1 NURTURING SCIENTIFIC IDEAS

Peacock et al. (2009) outline that early ideas about science and the world around us need to be nurtured. Primary school is the first formal setting of science education, and in this setting, the teachers are not usually science specialists (Bru et al. 2010). Nevertheless, it is crucial that teacher can share and convey theories with enthusiasm as the attitude of the teacher is pivotal in mediating learning (Burton et al.., 2009) Thomas and Banks (2009) highlight that the highest level of science qualification required to be a primary school teacher in GCSE science.

A Wellcome Trust Report (2017) found that two-thirds of teachers from their sample had not studied science beyond GCSE (or equivalent) and trainees are responsible for identifying and addressing gaps in their subject knowledge; it is hard to know where the gaps are if the teacher is not fully aware of the content. Suppose the teacher themselves chose not to continue studying science beyond compulsory school age. In that case, they may not regard science as an 'important' subject, and their personal experiences could have a direct effect on the amount or style of science instruction within the primary classroom. This has the potential to explain why Harlen (2008) states that many current teachers and even trainees in science have inadequate knowledge and lack of confidence in the fundamental concepts themselves. Murphy et al. (2007) do, however, comment that primary school teachers' attitudes and competency in science are improving, but there is still much room for development.

Epistemology in this area dedicated much of its efforts to know how we learn, and theorists believe that this could help with the teaching and consequent learning process. For example, following principles of Vygotsky's social constructivism (1978) means that children will come into the classroom with their own levels of understanding and perhaps teachers have to try to change a person's mind and their own current view of thinking about a particular matter (Driver et al.., 2004). Also, in science, teachers have to negotiate particular ontological views as teachers want students to acquire specific knowledge that has been agreed by the scientific community. To identify an example of the difficulties a teacher may face when teaching scientific concepts, Murphy et al. (2009 p.35) discuss an investigation in which a cup of tea was the context and the conditions of dissolving sugar the science concept. The learning outcome for an individual pupil was not achieved as the pupil was unable to apply the science to the situation as 'nobody drinks cold tea' and thus the context was not relevant or real enough to form any personal connections. This highlights the role of the science teacher is not only being aware of how to convey scientific ideas but also the difficulty in doing so when theoretical ideas of learning are also considered.

2.3.2 Specialised Science teachers across the educational levels

Osbourne, Simon and Collins (2003) discuss how important the chosen teaching sequences are when teaching science and proposed that it is the teacher's engagement in learning activities and stimulating the thinking of the pupils that have a greater effect on gains in learning. Thus, a teacher's own subject knowledge can have a considerable impact on the effectiveness of teaching; Thomas and Banks (2009) consider the training teachers have and therefore the confidence they possess in delivering specific scientific concepts. CASE (2014) discusses that teachers need to be equipped to deliver lessons to diverse groups of pupils. However, it also recognises how there is much diversity within the communities of teachers themselves and how their own training and views could influence their instruction.

When it comes to teaching science across the educational levels, there are several issues in terms of the workforce itself; many teachers are not specialised within the field they are asked to teach. Data from 2009 showed that out of the 17,000 maintained primary schools, there were only 6,000 teachers who had a specialism in science (CASE, 2014). Currently, there are several access points to becoming a qualified teacher in the UK that are linked to university: for example, BA, BEd routes with QTS, PGCE, School Centred Initial Teacher Training (SCITT) and Schools Direct. Most routes require GCSE grade C and above in Maths, English and Science, and post-graduate routes require a 2:2 in a relevant degree subject (Wellcome Trust, 2017). However, it was summarised in a review of initial teacher training (ITT) in the primary sector that not enough time was spent focusing on science in any of the ITT routes. As a result, teachers reported that "they did not feel suitably prepared to assess science and notably, providers' made little reference to the assessment of science in describing their courses" (Wellcome Trust, 2017 p. 4). It is recognised that high-quality ITT is vital to build teachers' confidence and prepare them to teach primary science well. The Wellcome Trust (2017) outlines how research finds that many primary teachers do not have a background in science or may not identify with science themselves, thus it is crucial that ITT prepares them well for their future profession.

At secondary school teachers are required to have a degree in their chosen subject, though this does not mean teachers are 'well qualified' as those with chemistry degrees will often have to teach biology etc. (Thomas & Banks, 2009). In addition to teachers not teaching their specialist subjects, Allen and Sims (2017) discuss the retention of qualified teachers and point to some evidence that science teachers are more likely to leave teaching than non-science teachers. This concern adds to the ongoing national shortage of chemistry, physics and maths teachers with recruitment targets in these subjects continuing to be missed. It was highlighted how teacher recruitment is at its lowest since 2013 and qualified teachers were leaving the profession at a higher rate than those entering (Burns, 2018). The article also further acknowledges the skills gap as it was noted that approximately a third of physics teachers and a quarter of chemistry teachers do not have a university qualification within the field. Thus, the 'specialised' teacher is less becoming less common in science (compared to other subjects) which could impact on engagement in science lessons and have an influence on motivation as many theories outlined in section 2.1 do refer to the teacher.

Therefore, issues regarding competency and confidence that would seem more prevalent at a lower educational level are also present at high schools. As Fensham (2004) outlines; teachers can be reluctant to discuss concepts with pupils who have interests that vary from their own specialities. This could have an impact on those academic pupils who wish to continue studying science as a failure to nurture this curiosity could have demoralising effects for the potential scientist. For those science educators teaching students beyond school age, there will be a variety of science courses that focus on a more academic or vocational route. However, Thomas and Banks (2009) suggest that each route has unique demands which require teachers to use appropriate methods and due to the nature of science and new advancements, this may mean that teachers in institutes are not at the forefront of their field. In addition to this, teachers are expected to "help the students explore an area of knowledge", which the teacher may not be familiar with. (Thomas & Banks, 2009, p.38). Whilst possible solutions are seen in WP as involving current graduates to deliver 'taster' sessions, Laws (1996) highlights that they may not have the appropriate training and skills to teach these concepts effectively. Thus, subject knowledge of teachers even at this higher-level pose pragmatic complications which are present throughout each phase of science education.

It was also found schools that offer a sixth form learning platform and have teachers who have a specialism within the subject they teach, are the lowest in physics, followed closely by chemistry (Research Council UK, 2008). This is also supported by findings in the 2010 report by the Department for Education (DfE) who reviewed the profile of teachers within the profession. The report found that the schools that have managed to 'break away' from this national trend of the decrease in the uptake of the sciences, have similar features such as; good leadership and able students, but maybe more importantly, science is taught by enthusiastic specialist teachers (Research Council UK, 2008). In Scotland, where this decline in the uptake of physics and chemistry is not as prominent, teachers, by law, have to hold university degrees in their chosen teaching subject to be able to teach Standard Grade Level students (which is the equivalent to A-levels in England and Wales). Thus, this provides a strong argument for ensuring teachers are secure and somewhat enthusiastic about the subject which they teach, particularly at a more advanced level.

The subject knowledge required by the teacher at all educational levels shows inconsistencies. As a learner, this can be evidenced by problems regarding the transition from primary to secondary education. Jindal-Snape and Miller (2008) discuss the favoured 'fresh start' approach adopted by many secondary schools which is explained by Braund (2009) as; secondary schools not considering previous learning or assessment information given, therefore leading to repetition. This leads to a lack of progression, stemming from a teacher's failure to recognise that science understanding is improving at a primary level (Thomas and Banks, 2009). This could account for findings that general science courses do not inspire and prepare pupils for science post-16 if pupils lose interest due to the repetition of some topics within the subject (House of Commons, 2002).

2.3.3 How schools and their teachers may have an influence on an individual's choice about their educational future as a scientist

Before the introduction of the National Curriculum in 1988 for schools in England and Wales, science was a subject delivered 'as and when' with little guidance as to what needed to be learnt (Thomas and Banks, 2009). Science was then integrated as a 'core subject' with the statutory curriculum. However, many teachers still took a relatively relaxed approach whereby there seemed to be little concern about new innovations within the science curriculum (Fensham, 2004 and Peacock, 2010). Tymms et al. (2009) found that at the time, many teachers did not rate their competencies high in this subject, and this could then account for this 'relaxed' approach. Therefore, the student experience of science would have been quite mixed, and as this generation who experienced this early wave of the National Curriculum become teachers themselves, this experience could have an impact on how they teach science and how frequently they do so. This latter point was reviewed in a review of the 'state of primary science' in the UK; it was found that 13% of the sample of schools did not teach science on a weekly basis to all year groups and that the average science is taught weekly for an average of 1.4 hours (CEF Research, 2017). In addition to these figures, the survey revealed that lower year groups received fewer hours of weekly lessons. Thus, younger children are not exposed to as much formal science would impact on motivation with the subject as section 2.1 describes how many of these interests are fostered at a younger age.

In a school setting, an individual pupil's home is the heart of their own culture, and these experiences may not be shared amongst peers (Jegede and Aikenhead, 2004). However, all pupils must complete a shared science course that has specifications that do not always account for these multicultural differences and indigenous knowledge that is not shared by the Standard Account of Western science (Cobern and Loving, 2004). Hodson (1998) identifies the struggle teachers' face in terms of the delivery of the science curriculum to a wide variety of learners; they need to take into account each child's background to allow assimilation, appropriate questioning and accessible language to encourage each child to succeed. Success is important in school science as Gorard and See (2009) explain that without it at a lower key stage, pupils are less likely to choose to study science beyond this. Whilst FSM and Pupil Premium (PP) is a good indicator of a school's demographic, Gorard (2011) explains that schools can be compared in terms of achievements. This means that the proportion of children choosing science vary between schools, and the background of these children can be linked to their decisions.

2.4 SCIENCE OUTREACH INITIATIVES

One of the research questions aims to explore how science outreach can become a more sustainable intervention tool within the classroom. Therefore, this section will explore what science outreach is and what is often involved with this global practice. The findings from this section will inform the primary data collected in this research study as it will provide a more global representation of what science outreach programmes may look like. It also indicates which types of organisations are involved with these endeavours and highlights which issues will be considered when designing the 'optimum' model for outreach.

2.4.1 What is science outreach?

The Royal Society (1985, p.9) outlined that "…better public understanding of science can be a major element in promoting national prosperity…" which, according to Whitelegg (2009), in the 1980s and early 1990s led to an increase in funding due to concerns about science being overlooked. However, the model to promote Public Understanding for Science (PUS) followed a deficit model of knowledge transfer; this received several criticisms in which Holliman and Jensen (2009) called for a more sophisticated relationship between the sciences and society to promote higher-level thinking skills.

In the UK, this led to the shift from the PUS which was a top-down, transition mode of communication, to upstream Public Engagement in Science (PES) whereby the public were invited to become more central and active in discussions about science (Van Est, 2011). Historically, individual scientists have always shown interest in sharing their work with the public. However, more recently, science outreach has become more organised and high profile, as science education is seen as more accessible (Whitelegg, 2009). Economy and democracy are considered important features of this shift, as Whitelegg (2009) described how communicating science effectively can inspire the future science and engineering workforce. Not only this, but it also ensures that all citizens can engage with the decision-making process about science and technology in today's society. Vincente (2014) implies that the days of science being a solitary activity in terms of both doing science and communicating it is something of the past. He continues to describe how outreach is now not just about helping the public gain some scientific understanding, but also ensuring that society appreciates why the government (thus the taxpayer) should support investment in science.

Thus, science outreach work is an umbrella term for a variety of activities used to promote science communication and informally contribute to science education. Science outreach is also known as Education and Public Outreach (EPO); these activities are often organised by research institutes, universities and other institutions such as museums. Falk and Needham (2011) discuss how these experiences feature a range of sources that may support science learning. The activities may involve: public talks/lectures; visits to schools; workshops for students and teachers; supporting science fairs and providing resources and information online (Royal Institute, 2017; VSVS, 2017; Canadian Space Agency, 2016). Leuhmann and Markowitz (2007) investigated some reasons teachers may choose to engage with these science outreach activities as they interviewed eight secondary school science teachers during a yearlong partnership between their schools and a university.

When teachers were asked about their motivations for being involved in this partnership, they often linked it to increased access to learning. Although science learning can often be less defined in science museums and centres, Whitelegg (2009) describes how Generic Learning Outcomes (GLOs) can be used to model and evaluate impact (Fidler, 2010). These do not just address the cognitive outcomes of these informal settings, but also other critical social skills. This additional aspect is also important when considering other reasons teachers chose to engage with outreach as it was depicted by Tuah, Harrison and Shallcross (2009) that teachers perceived a common benefit of these outreach activities were the ability to experience science outside of the classroom.

The types of science outreach activities outlined above have the potential to reach and impact upon a large number of students and the public. For example, Sanford University estimates that its lab and outreach team encounter approximately 10,000 5-18-year-old (K-12the grade) students each year and events at the university laboratories reach about 2,500 members of the public (Sanford Laboratory, 2017). Fundamentally, science outreach work is often described as a fun and satisfying venture, but uncertainty of its value (Bogue, Cady and Shanahan, 2013).

2.4.2 A COMMON FRAMEWORK OF SCIENCE OUTREACH INITIATIVES

Science outreach work often takes the form of partnerships between university departments and particular schools, based on their location. Gumaelius et al. (2016) suggest how Universities have recognised the decline in interest in STEM education and Careers since the 1990s, due to the decline in the number of these types of graduates. Therefore, these science outreach programmes were often established as part of HEI recruitment drives within this field, taking on more responsibility for their role in community engagement. DeCoito (2016) agrees that universities have a pivotal role to play in fostering STEM learning for all school students and that it should assist with developing STEM

1. Active learning through the use of hands-on activities.
2. Inquiry based learning.
3. Curriculum supplements.
4. Engaged role models.
5. A focus on younger students
6. K-12 Teacher involvement.

Figure 2-2 Six common approaches used with 59 different K-13 outreach programmes in the USA (Jeffers et al., 2004 p. 95-108)

skills, interest and achievement within this field.

Jeffers et al. (2004), looked at the design of 59 different outreach programmes in the USA, which is the country that has published the most reports about university coordinated outreach programmes (Smaill, 2010). Although their focus was on engineering, they were able to identify six common approaches used as part of these STEM outreach programmes (outlined in **Error! Reference source not found.**). The framework outlined b y Jeffers et al. (2004) is an effective tool to evaluate different science outreach programmes as it provides some common approaches to ensuring the activities are engaging. For example, Gumaelius et al. (2016) used Jeffers et al.'s (2004) framework to analyse the pedagogical framework of eight different STEM outreach programmes in five European countries. Additionally, the framework can be used as a checklist for those who design these activities as the approaches outlined by Jeffers et al. (2004) are often the areas that are researched or debated when implementing programmes. When considering the age of the students within these programmes; elementary education is for students aged 5-10 and kindergarten (K-5th grade) is the first year of this level of education, middle school (6th-8th grade) students are generally aged 11-13 and high school (9th-12th grade) is for students aged 14-18 (Fullbright Commission, n.d.).

2.4.3 What we can learn from a worldview of these programmes

Science outreach programmes are not just limited by country; there are examples of different outreach activities across the globe (Table 2-1 on the next page). A summary of some of these science outreach initiatives are highlighted in and further explained in Appendix A: A snapshot of different science outreach programmes across the globe. From the description of these different initiatives, it is clear that there are similar features which are present in outreach programmes in different countries when using Jeffers et al.'s (2004) framework. Hence, the constraints linked to engaging with the programmes are often quite similar. It is also promising to see how even in less developed countries, science outreach is given a platform in schools and the benefits of students engaging in these activities are similar to those found in more developed countries.

Table 2-1 Examples of some science outreach programmes across the globe

Country/ Continent	Specific Example of Science Outreach programme(s)
USA	Has the most published examples of outreach initiatives (Jeffers et al, 2004). These often take the form of a university-partnership, such as; University of South Dakota medical school and East Carolina University; both offer teacher development programmes.
Canada	The Scientist in Schools programme is aimed at 5-10 year olds and includes lots of half-day workshops (Shanahan et al, 2011).
UK	'The Blue Marble' project runs hands-on workshops for 5-11 year olds (Muller et al, 2013). Bristol ChemLabS provide a variety of chemistry outreach programmes and has been running for over ten years (Glover et al, 2016).
Denmark	The 'Univeritarium' contains interactive natural science exhibits which can be experienced by families and schools (Gumaelius et al, 2016).
Norway	'Space Science Suitcase' offers tools for schools to be able to monitor space activity (Olafsson et al, 2009).
Sweden	'Vattenhallen' takes place at Lund University and facilitates visits to the university. Stockholm University runs an oversubscribed summer school (Gumaelius et al, 2016).
South Korea	Within the Naro Space Centre, there is the Space Science Museum which is designed to provide 'edutainment' (Lee et al, 2011).
Australia	In Canberra, there is a 'Science Extension Day' which focuses on partnerships across a range of educational levels. Three schools approached the University of the Sunshine Coast to design a chemistry outreach programme to assist high school students (Fletcher, 2016).
Africa	Computer-aided learning outreach activities aim to extend the 'normal lesson' in disadvantaged schools (Hartley et al, 2008). Several Geoscience outreach programmes were initiated following the International Year of Planet Earth such as; student debates, science kits for schools and competitions (De Mulder et al, 2014).
Middle East	In Iran, an astronomy magazine has provided outreach national outreach events for a range of audiences (Tafreshi, 2011). There is also a mobile science laboratory that provides a platform for students in rural schools in Turkey to carry out practical activities (Erol et al, 2016)

It is described how well-designed activities can engage learners in a more authentic experience; this will therefore be able to provide a better context for learning, hands-on activities and change perceptions (Illingworth and Roop, 2015). Bogue et al. (2013) also discuss how these experiences provide benefits to those delivering outreach sessions as they describe how outreach work provides an opportunity to develop leadership skills whilst also promoting their own community to those beyond the usual membership.

Therefore, it is considered that when executed effectively, science outreach programmes have a plethora of benefits for not only students in schools but also to those who deliver the programmes and many different stakeholders in science.

2.4.4 Science outreach as a CPD opportunity for teachers

CPD provides opportunities for teachers to network and learn more about their profession; most teachers who engage with these types of courses in the UK may only attend one session a year, but Allen and Sims (2017) find that this still does have a positive effect on teacher retention. It is proposed that attending CPD events for science teachers assists with their own enthusiasm and engagement with the subject and will maintain their interest in the profession; thus, this will have a positive impact on the lessons they teach (Allen and Sims, 2017). Examples of outreach programmes in STEM outline how teachers are very much included in the structure of both of these programmes (Goodman, 2002; James et al, 2006). Illingworth and Roop (2015) suggest the widespread benefits of science outreach are mutual for learners, teachers and researchers. Goodman (2002) reiterates this idea of the mutual relationship between teachers and scientists, stating that whilst teachers are able to learn and experience science from the scientists, the scientists themselves are also able to learn about pedagogical techniques. James et al. (2006) also share a similar view as they describe teachers as 'lifelong learners' and therefore, including professional development will assist with the recruitment and retention of teachers. It is emphasised how these school-university based partnerships allow alignment between bodies who are essentially working towards the same goal for their students and have to overcome obstacles or challenges which are more challenging to tackle individually (James et al.., 2006).

It is found that collaboration between teachers and educators can create a merged community of practice where all parties receive benefits. However, Szteinberg et al. (2014) warns that quite often the CPD is delivered as an outreach effort itself and teachers may feel that this CPD has been done to them by an outside organisation. However, a project was devised to bridge gaps between educational research and practice whereby both bodies centred their thoughts on investigating students' abilities to apply chemical thinking and engaging in authentic tasks. Szteinberg et al. (2014, p. 1401) describe how this type of professional development for teachers is important, and a key to improving student learning as "teachers who are involved in research become better educators as they constantly reflect on their own practice". In this project, the teachers provide selfevaluative results of their involvement in the research via a questionnaire. It was found that both teachers and researchers were able to approach this task with the curriculum in mind, and the responses from the questionnaire were deemed that that project had been a success. Several teachers (from both middle and high schools) described how their own perceptions changed as their views and comments were utilised by the research team and not just dismissed, which is what they had initially thought. One response from the teacher's questionnaire describes a local professor who had already worked with some of the local schools; this individual suggested that the reason this project worked was down to the fact that there had been an existing relationship and trust and respect between both groups was quickly established. This meant that teachers felt they were able to be open and honest in meetings to share their thoughts and ideas. The success in terms of teaching encouraged teachers to rethink their own practices and have more 'open' tasks for their students. Teachers who were involved also spoke how it had increased their confidence in interpreting student's thinking (Szteinberg et al, 2014).

2.5 CURRENT CHALLENGES OF THE DELIVERING OF SCIENCE OUTREACH WITHIN THE CLASSROOM

Understanding what barriers may exist when trying to deliver these programmes is useful when considering the effectiveness, frequency and design of these programmes. This is important and often referred to in literature about outreach and will be informative when considering how the model designed in phase one and two of these research process by acknowledging and alleviate some of these issues.

2.5.1 PRAGMATIC ISSUES ABOUT THE DELIVERY OF THE PROGRAMME

Shanahan et al. (2011 p. 140) describe how science outreach programmes may be costly to implement, and it is often the lower-achieving inner-city schools which have the higher amounts of students from backgrounds of low SES. Therefore, regardless of the impact on this demographic, if the cost is an inhibiting factor, the child may not have the chance to experience these interventions. Worryingly, Lee et al. (2008) suggests that underachieving elementary schools experience a reduction in science instruction as there is the apparent need to focus on numeracy and literacy. This fits into Bourdieu's (1990) ideas about 'cultural capital' as it is discussed how schools are essentially designed for the 'middle class', whereby it is assumed that all children have equal access to it. Thus, underachieving schools may face problems concerned with both the resources and equipment available at the school itself and those children who attend these schools cannot be assumed to have equal access to 'cultural capital' beyond the school as well.

A further, less obvious issue surrounding the delivery of the science outreach programmes is about who actually delivers the activities as they have the potential to become 'role models' for some individuals. Cridge and Cridge (2015) discusses the 'look' of the outreach facilitator and its potential to cause a group of learners to disengage with the activities. If the 'face' does not reach out to the audiences they are trying to attract because of differences in race, age and gender then it can mean that these 'role models' are not accessible. This links to ideas about the construct of science itself and how different cultures place different values on science; if science is seen as a worthy pursuit, then they are more likely to be encouraged to engage with the subject (Lemke, 2001). Gale et al. (2010) discuss how these outreach activities are designed to raise aspirations and therefore if an individual does not receive encouragement from home then these 'role models' can showcase possibilities that have not been presented within their own immediate environment. Therefore, depending on the dynamics, enthusiasm and background of the outreach facilitator, this can affect whether those accessing the outreach activities will engage with the content of the programme. It is important to note that whilst the influence of role-models is acknowledged; their impact can be compromised by the on-going and direct influences of parents, teachers and their peers (Cridge and Cridge, 2015).

2.5.2 What is the optimum age to deliver these programmes?

The age at which interests develop have been discussed within this chapter and ideas with strong theoretical underpinning: However, anecdotal experiences explored by Maltese and Tai (2010) depict famous scientists being interested in the subject from an early age. This supports findings from a study conducted by the Royal Society (2004) which found that out of 1100 practising scientists and engineers 63% of them expressed they had such career aspirations before the age of 14. When looking at the data obtained from the study by Maltese and Tai (2010), it was found that from a sample of 116 interviews from scientists who had experience at PhD level, were post-docs or were actively involved in the graduate school, that 85 of these participants contained data regarding early interest in science. From these chemistry and physics students, it was explicitly found that 65% of the participants explained how their interest in science began before middle school years (age 11-14). When also exploring what it was that interested these individuals to remain within the field, 40%

of the participants described how their interests stemmed from a school or educational based experience, which reaffirms the important role of teachers and opportunities (such as outreach initiatives) within the science classroom. These examples indicate how the age at which these outreach activities are delivered become increasingly important, especially as Careers Education, Information, Advice and Guidance (CEIAG), which is impartial career advice offered to pupils, is only present from Year 8-13 in England and Wales (CASE, 2014). Especially as Bennett and Hogarth (2009) describe how positive attitudes towards school science significantly dropped between the ages of 11 and 14.

Shanahan et al.'s (2011) review of the SiS outreach programme is interesting as it draws on arguments about when science outreach work is at its most effective. Wilson and Chizeck (2002) suggest that too often, these types of programmes are aimed at middle school and high school students, but the curiosity of the child should be nurtured at the earliest age possible. This is evidenced in the study described previously by Maltese and Tai (2010) along with Koehler et al. (1999) who also targeted their science outreach work at 4th-grade elementary students (aged 9-10 years old). Windsor and Bailey (2016) also review the impact of a chemistry outreach programme on students in their penultimate year of high school and found that at this level there was very little change in attitudes towards science evidenced. They did, however, discover that there were some learning gains of students who participated in a series of events which supports ideas that even though science outreach programmes may not change minds of high school students, they do in fact improve learning in science (Thomas, 2012). However, outreach aimed at younger learners such as, SiS, which is designed for elementary school students, is in a strong position to develop positive attitudes towards science. In turn, this makes the impact of such programmes hard to monitor due to the time-lag and the variety of other factors which may have a significant impact on career choice (Shanahan et al., 2011). This was a similar issue with being able to measure a student's long-term achievements after being involved with the programme.

2.5.3 Lack of support for those who facilitate these outreach activities

Alexander et al. (2011) describes a programme which uses postgraduate students to deliver a science outreach programme to a lay adult audience which has targeted over 1000 senior adults in the community. The students prepared short presentations and allowed time for questions and discussion about their topic. It was also an opportunity for the audience to share their own experiences and highlight any concerns they had surrounding the area of science presented. Reflections upon the project indicated that topics which were more related to the target audience such as, hearing or vision loss, engaged a higher number and that the use of too much scientific language could be a challenge. However, whilst these reflections could feed into improving the design of the programme, a more problematic challenge of the programmes was that some of the members of the faculty did not support the notion of outreach work, so have been found to discourage their postgraduate students from taking part (Alexander et al., 2010). Goodman (2002) also similarly found that some members of staff at USDSM could not find any value in the outreach programmes provided, and they receive little encouragement from their colleagues to do. This is disappointing when considering programmes such as the 'Let's Talk Science Partnership Program', which is operated through Canadian universities (Eng and Febria, 2011). Eng and Febria (2011) focused on the benefits for the facilitators in these activities. They found that the science students volunteering in schools and community centres as mentors become more confident in presenting and developing their communication skills to be able to interact and engage a broader audience.

Wilson and Chizeck (2000) also find that time for university representatives to visit the science classroom is limited to, at most, once a week. This is to be expected in many cases due to their own professional commitments. However, sometimes this restriction is not due to professional endeavours but because of lack of professional support from some of their more senior colleagues. The Royal Society et al. (2006) explored scientists and engineers' attitudes towards science communication and found that facilitating these events were perceived as 'light' and 'fluffy' science. Women, in particular, struggle with this conflict and describe how even though they may wish to be involved they would rather not as they do not want to reinforce the negative gender stereotypes of women in science. Smidt et al. (2009) also refer to this survey, describing how competitive funding streams in research can also affect willingness to take part in outreach initiatives. Whilst the UKRI (2019) have renewed their commitment to public engagement, for many this is still not seen as a priority (Smidt et al. 2009).

2.6 CAN SCIENCE OUTREACH PROGRAMMES HAVE A SIGNIFICANT IMPACT ON AN INDIVIDUAL?

Banerjee (2015) calls for the diversification of those who continue in STEM professions and highlights that this could bring about a more innovative and responsive workforce which could further address the STEM skills gap in the UK. Therefore, the government continue to fund STEM enrichment programmes to motivate and enthuse a broader range of students to stay within the field (Banerjeee, 2018). This is because of the higher the number of pupils eligible for free school meals at a school, the more likely that school is to have poor maths and science GCSE results (Banerjee, 2015). However, Banerjee (2017) identified that whether pupils attend STEM enrichment programmes has no notable impact on students continuing to study STEM subjects at A-level. Thus, there is a requirement for more rigorous evaluations to be able to understand what works in order to build on the best initiatives to achieve better results by spending the same amount of money (Banerjee, 2015; Banerjee, 2016). Part of the problem may be centred on how this type of data is collected; to actually monitor whether these types of programmes or other types of outreach work are having an impact there is little reach within this field. Bogue et al. al (2013) also describe how stakeholders will often measure success somewhat superficially and simply consider as what "looks good", such as; numbers of those who attended, the opinions at the time and really it is hard to monitor impact over time which links back to the issues discussed at the start of this section.

Whilst measuring the impact of an intervention is difficult, Falk and Needham (2011) explain that understanding of science is derived from a myriad of sources, and the infrastructure of this may be complex. This study asks teachers about the perceptions of engaging with science outreach programmes and the perceived effects on the students who are involved. Thus, the type of 'impact' is not pre-defined as the focus is on developing a model to be used as a framework to inform the design and delivery of these programmes. Then those who engage with these can then decide how to effectively measure the impact of their activities. Some of these possible tools are discussed in the next section.

When considering the challenges involved with understanding whether something has had 'an impact' Falk and Needham (2011) addressed this challenge as they measured responses over a number of years which would allow changes over time to be more visible. In another study which aims to measure impact, Bogue et al. (2013) suggest that there should be pre and post surveys which evaluate the effectiveness of such programmes. An example of a scheme which did collect this type of data was conducted by Shanahan et al. (2011), whereby responses of elementary school students (*n*=811) in Ontario, Canada was collated. These students had participated within a sizeable two-year study conducted by the Scientists in School (SiS) outreach program, and they were questioned about, their enjoyment, interest, perceptions of role modelling and future career choices in science.

They found that girls and students at lower-achieving schools found the program more enjoyable than other groups of students, and they felt that the visitors had provided a positive science role model. Shanahan et al. (2011) also provide a critique of their own data, suggesting that their study cannot measure students' later achievements or the long-term effects of participation as these impacts are hard to monitor due to the fact many other factors may come into play when students make decisions. This could offer an explanation of why, thus far, there is seemingly very little research which monitors the impact and sustainability of outreach programmes and further provides a rationale for this area of research. Whilst this may alleviate some of the lack of transparency when it comes to measuring impact, it is suggested that many of these STEM outreach programmes do operate or continue to measure changes over a more extended period of time (Lakanen and Isomöttönen, 2018; McGill, Decker and Settle, 2015).

Therefore, when considering the development of the model in this research, it should aim to inform programmes that will be longitudinal in nature based on the discussion presented here. Whilst, data collected from this study will highlight barriers teacher may face when engaging in longitudinal science outreach projects it is also worth noting more expansive programmes which have managed to operate over a long period of time and support a range of age groups. For example, Bristol ChemLabS is based within the Chemistry department at Bristol University and has been operating for over 10 years (Glover et al., 2016). Shallcross et al. (2013 p.39) explain how this initiative was derived "in 2005 as the Higher Education Funding Council for England (HEFCE) invested about £300 million to establish 74 Centres for Excellence in Teaching and Learning (CETL)." Bristol ChemLabS was a CETL dedicated to chemistry and is not only still operating beyond the initial five years if funding, but also expanding. At the time of publication, Glover et al. (2016) estimated that over 25,000-30,000 students engaged with Bristol ChemLabS' outreach provision on a yearly basis. Due to the time and scale of this chemistry outreach programme, it allows an impact on both teachers and learners to be documented, as well as sharing an effective practice that has made the project a success. Further information regarding the impact of Bristol ChemLabS is in Appendix B: An evaluation of a successful model of science outreach in the UK, which will be used to further inform the design of the model developed in this PhD study.

2.6.1 Examples of how science outreach programmes may impact upon school experiences

Cleaves (2005) conducted a study in the UK in which 69 students were interviewed over a four-year period from Year 9 to Year 11. The study found that even the students who planned to continue within the field of STEM did not enjoy secondary school science; it was only because of their view of the 'bigger picture' of their future careers that they chose to continue studying STEM subjects. Therefore, it is to be anticipated that those who reported these same negative experiences of secondary school science and did not have any preference for a future career could choose not to continue studying within this field beyond school age. It was also found that at the high school level, negative influences are deemed to be much more powerful than positive experiences (Cleaves, 2005). This suggests that if students do not enjoy science at high school, but report how they do enjoy science outreach activities, then these types of programmes are crucial to maintain and possibly reignite interest within the subject.

In studies that look at the effects of SES in the UK, it is often hard to produce clear results due to the well-established compulsory schooling system, as many additional factors could influence an individual's experience, e.g., teachers, school hours, methods used, class size (Gorard, 2008). In countries where education is not compulsory, or there are divides due to faith or funding, SES and attainment have a stronger relationship. Gorard and See (2009) worry about a growing correlation and suggest that the reason that students with a low SES status choose not to study science after school is due to their early experience of school science. Wright (2006 in Gorard 2008) suggests that whilst there is a similar effect of the gap between SES and attainment, science is specifically affected by the teaching methods used within the subject. Thus, some accountability needs to be given to the nature of the school, and this should be addressed to inspire pupils to want to study science. Murphy and Beggs (2001 in Gorard and See, 2009) suggest reasons for this drop in interest/attitude are the lack of experiments in which children are able to find things out for themselves and repetition that occurs through the key stages.

2.7 CHAPTER SUMMARY

Braund (2009) describes the close relationship between enjoyment and attainment in science and Gorard and see (2008) state that prior attainment and attitudes towards science can have the biggest impact on any individual continuing science to undergraduate level. Thus, as this study aims to explore whether outreach work can have an impact on choices made regarding further science study or not, it is important to consider if these interventions have an impact on enjoyment. When considering the links between interest, engagement and outreach work, it is interesting to focus on the discussion of Maltese and Tai (2010) who find that students are often not engaged by the 'autocratic' way science is represented in schools. In addition to this, students expressed that they did not enjoy learning science as a separate entity to the world around them. It is suggested this presented a decline in interest in science. Thus, as the purpose of many science outreach programmes is to engage and provide a contextual value for science, these interventions may help to alleviate these concerns. In addition to this, research finds that individuals from a 'disadvantaged background', such as coming from a family with a low SES, then they may not receive additional support and encouragement from their parents and therefore, it is interesting to consider if interventions such as outreach work can have a significant impact on this demographics' enjoyment and attainment in science.

Greany et al. (2014 p.9) describe how "so far, in some Western countries, there is little evidence that governments support moves beyond rhetoric" as there seems to be a lot of talks and doing but little measurement of whether it meets its programme aims. This is confirmed in a report by the UK National Coordinating Centre for Public Engagement who found that national policy regarding university–school partnerships are disjointed, lacks coherency and is unsustainable (Greany et al., 2014). Bogue et al. (2013) outline some suggested key practices to outreach success, these include assessment based programming; understanding what works and what needs work; and using proven practices, whereby you are not 'reinventing the wheel'. Their descriptions provide an account of outreach work that is realistic, can assess any impact, is research-based and have ideally been 'tried and tested'. Hence, there is a lower element of 'risk' whereby the scheme itself is not successful. In addition to the programme content itself, Illingworth and Roop (2015) suggest that the key recommendations for successful science outreach work are to involve teachers, continually evaluate the activity itself and increase the professional recognition of the facilitators of the programme. Therefore, in the context of this research, they are crucial to facilitating the design of the model and informing further literature within the field.

Thus, this study will draw upon experiences of the teachers to further inform how engaging with science outreach programmes may affect the particular demographics of learners. It also aims to highlight how and why they engage with these types of programmes to provide a further understanding of how learners access the programmes in the hope to reach a wider audience in the future. It is anticipated that the responses to these unanswered questions are depicted within the research aims identified in Chapter 1, which shape the structure and design of this PhD research study.

CHAPTER 3: METHODOLOGY

This chapter discusses the chosen research methods used to collect primary data for this doctoral research study and the chosen tools to analyse the data. These approaches are justified in the chapter, framed in the context of the chosen research paradigm for this study and it also discusses the reasoning why mixed methods were the chosen research methodology. The structure of the research adopts a two-phase approach (summarised by in 1.6), whereby a two staged Phase One lead into a single stage Phase Two data collection. Therefore, this chapter explores each phase of the study for this PhD research.

3.1 Paradigm Rationale

This chapter considers the epistemological and ontological beliefs of the researcher which were essential in choosing the most suitable research paradigm and approach to this doctoral research study. In research, paradigms present a different way of connecting social experiences, reality and ideas etc. (Blackie, 2007). Kuhn (1962) highlighted how research paradigms are an agreement between scientists about how problems are understood and how they could be addressed; in other words, it is the shared set of beliefs between a community of people. For example, the researcher may decide to refer to themselves as a positivist, a constructivist/interpretive, or a feminist depending on their understanding of how they feel reality and knowledge are linked (Cohen et al, 2018). In order for a researcher to identify their own research paradigm, often they consider a set of questions such as (1) 'What is reality?', (2) 'How does the researcher know something', and (3) 'How can the researcher find out about something' (Guba, 1990). These questions can namely be placed into three categories which are, ontology, epistemology and methodology.

Scotland (2012, p.9) explained how each paradigm is built on ontological and epistemological assumptions "and as such, the philosophical underpinnings of each paradigm can never be empirically proven or disproven." These differences in assumptions are reflected in the chosen methodology and data collection methods to answer particular research questions. In educational research, Scotland (2012) highlighted that the most common research paradigms are positivist, critical and interpretive. However, this PhD study adopted an alternative research paradigm of pragmatism.

3.1.1 Pragmatism

Morgan (2014, p.1046) discussed a simplistic view of pragmatism which places the idea of "what works" in research. He compares this to the simplified descriptions of other research paradigms that exist in a post-positivist and constructivist world. Guba (1990) conversely recalled how there is now more comprehensive understandings of many of these paradigms, although pragmatism has been omitted from these discussions. Morgan (2014) argues that the pragmatist approach is frequently linked to mixed-methods research (MMR) and there has been a lack of philosophical debate regarding this paradigm. Thus, a brief history and development of the pragmatism philosophy is presented in the following section, as well as an overview of how this paradigm has informed this doctoral study.

3.1.1.1 The Classical Pragmatists

Rylander (2012) discussed how pragmatism was derived from 'The Metaphysical Club'; which included philosophically lawyers from Harvard University in Boston; some active members included Charles Sanders Pierce and William James. They published papers that discussed ideas and beliefs, but in 1989 it was their paper entitled 'Philosophical Conceptions and Practical results' that introduced the idea of pragmatism. John Dewey was a follower of both Pierce and James and is now recognised as one of the most valuable advocators of this pragmatist philosophy (Ilica, 2016). Dewey continued to further develop and influence the tradition of Pierce and James, who are collectively known as the "classical pragmatists" (Rylander, 2012, p. 3).

3.1.1.2 John Dewey

Having a historical understanding of a philosophy allows the researcher to see how the development of the pragmatism paradigm aligns with their views. Thus, it is important to start with the work of John Dewey who focused upon the human experience (Morgan, 2014). Dewey and his fellow 'classic pragmatists' steered away from metaphysical discussions which centred around nature of reality or truth and favoured a starting point that was rooted in the experiences of living in an emotional, social and contextual world (Morgan, 2014). Goldkuhl (2012, p.7) adds that "the essence of pragmatist ontology is actions and change; humans acting in a world which is in a constant state of becoming". Dewey determined that the world changes because of actions and beliefs, and there is an inseparable link between what we know and how we act as humans. Dewey's work (conducted in the 1920's) centred on two questions that considered the sources of our beliefs and the meaning of our actions (Dewey, 2008). It was proposed that these two questions were linked, as beliefs were interpreted to generate actions and in turn, actions are interpreted and generate new beliefs. Therefore, these experiences create (new) meanings by connecting beliefs and actions.

For the most part, many experiences are what Dewey described as a *habit*, by which many of our actions are unquestionable (Dewey, 2008). Morgan (2014) provides context for this notion, as often beliefs, we have acquired from previous experiences, allow us to operate in a somewhat semi-automated manner. Rylander (2012, p.16) highlights how Dewey developed his idea of *inquiry* as the opposite to this *habit*; in which "a situation is recognised as problematic", and this process then requires a series of self-conscious decision-making steps. The steps include reflection and then providing a resolve via an action (Morgan, 2014).

Goldkuhl (2012, p.7) considered how this process of inquiry, "is central to the application of pragmatist thoughts in research". Dewey (2008) suggested that whether these actions are due to *habit* or *inquiry*, they occur within a specific context. This sense of historical and contextual dependency means that an individual may not have sufficient past experiences to be able to guide action; however, this is where the sense of *emotion* plays a part in Dewey's model of inquiry (see Figure 3-4). Therefore, following this mode of progressive inquiry allows a possible solution to emerge from an *idea* (Rylander, 2012). Rylander (2012) described how ideas are what facilitate operation and actions, resulting in them becoming the proposal and plans for inquiry. For when trying to solve a problem, Morgan (2014) contemplates how Dewey presents a very blurred boundary between everyday situations and research; the latter of which is simply a task performed more carefully and taking note of one's actions. Thus, when establishing common sense or forming scientific concepts, the inquiry process will often follow very similar patterns (Rylander, 2012). Therefore, understanding Dewey's concepts are important when considering adopting this paradigm to this PhD study.

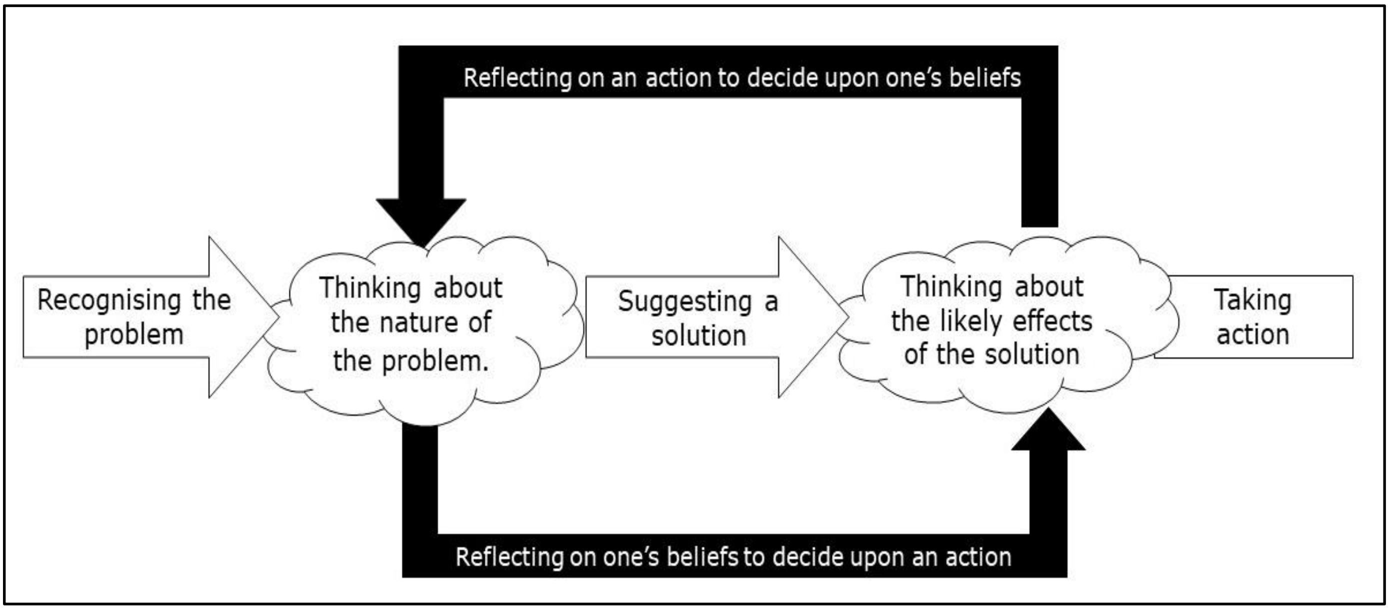


Figure 3-1 Dewey's model of inquiry. Adapted from Morgan (2014 p.1048)

3.1.1.3 Neo-pragmatism

By the mid-twentieth century, pragmatism had lost a lot of its followers in America but upon the release of Rorty's (1982) book entitled 'Consequences of Pragmatism' there was a revival in attention for this philosophy (Allen, 2008) Rylander (2012, p.27) outlined how Roty (1982) criticised "the tradition in philosophy" and made "American Pragmatism philosophically interesting again" (Allen, 2008 p.4). Thus, the key differences between Classical and Neo-pragmatism are summarised in Table 3-1 below.

Table 3-1 Main differences between classical pragmatism and neo-pragmatism (Malachowski, 2010)

Classical pragmatism	Neo-pragmatism
Discusses how experiences influence new beliefs	Discusses the use of language to express concepts
The acceptance of the "scientific method."	Abandons the idea of the "scientific method."

During the rise of neo-pragmatism there was also a movement introduced by Rorty (1967) known as 'the linguistic turn' (Rylander, 2012). The idea of this was to highlight the importance of language in solving philosophical problems by focusing more upon the actual meaning and understanding of the language used Noaparast (2015, p.1) suggests that neo-pragmatism placed more emphasis on language and this is essential in educational research, as "language is a pivotal point in educational relationships". Rorty (1967) concluded that this linguistic turn allowed pragmatism to 'break away' from the traditional pragmatism, which was not as clear with the work and ideas of the classical pragmatists.

According to Rylander (2012), Hilary Putnam is also recognised for his contribution to the revival of pragmatism. However, the direction of Putnam was somewhat more conservative and rather than moving this paradigm to new grounds, he focused upon the useful aspects of classical pragmatism (Malachowski, 2010). Putnam also explored the ideas of antiskepticism and fallibilism being linked to pragmatism by suggesting that to doubt something requires just as much justification as a particular belief and that no justification of a belief can guarantee the absolute truth (Rylander, 2012). Both Rorty and Putnam acknowledged the importance and significance of the work of Dewey, but their progressive ideas led to this new age of pragmatism.

3.1.2 WHY PRAGMATISM?

Despite a clear rationale for pragmatism, it is often considered that a pragmatist approach can be a way not to have to 'label' oneself to a purist ideology, but advocates combining strengths of different approaches (Bryman, 2012). In pragmatism, Goles and Hirshheim (2000) discussed how a pluralist position may be adopted, allowing the most suitable methods to be selected to find a solution to a problem. Goldkuhl (2012), suggested this reasoning for why a researcher may conduct pragmatist studies with interpretive thinking and data collection methods. Therefore, this idea of being allowed to combine the essence of philosophies has been useful when considering the challenge of being a researcher in science education. 'Science' that is usually associated with a positivist paradigm and 'education' that is usually associated with an interpretive approach combines two distinctive paradigms. Rylander (2012) proposed that pragmatism spans over philosophical positions. Morgan (2014, p. 1051) states it is a paradigm which "accounts for the accomplishments of previous paradigms without the need for metaphysical assumptions". This, in essence, considers the pragmatist as someone who wishes not to label or accept a specific view of knowledge (Malachowski, 2010).

Malachowski (2010, p.12) outlined how the "new pragmatists are inclined to view classic pragmatism as a rough and ready, but luminary, source of guidance…" and it was neo-pragmatism that was acknowledged for revising the interest in this paradigm. A key difference is that the neo-pragmatist Rorty (1996) steered away from the acceptance of the scientific method; this does not align with the nature of this project and the views of the researcher. The researcher's views about scientific ideas closely align with those of Thomas

Kuhn who adopted a fallibilist stance in science. He believed that scientific paradigms should be assumed to be false and that it is trying to disprove these ideas and not being able to, that makes them more likely to be true (Kuhn, 1996). Whilst this aligned with ideas of neo-pragmatism; Khun was critical of the 'linguistic turn' in neo-pragmatism, as he discussed how the use of language to represent reality stems from the act of future observations (Kuhn, 1996). For example, the term 'electrons' was derived from experiments which allowed those at the time to share an understanding of reality, this word 'electron' then stimulated new experiments to discover more about this paradigm which in turn has presented us with new languages. This means that the focus on language in neo-pragmatism can be somewhat tricky. In attempting to determine the researcher's position, it is Dewy's (1931) pragmatist stance that reflects the purpose of this research study, as he described how knowledge should be constructive and useful to provoke action, which aligns with the researcher's thought processes.

As this doctoral study has a focus on the creation and development of a model, the pragmatist approach ensures the data collected will provide the most suitable information to be able to encompass teachers' views by focusing on the different strengths of different paradigms (Johnson & Onwuegbuzie, 2004). The design of this research study allows knowledge gathered to be used to suggest an 'optimum' model for science outreach programmes. The derivation of this model closely aligns with the stages of Dewey's model of inquiry (see Table 3-2 on the next page). Therefore, this doctoral research study, adopted a classic pragmatism approach due to its faithful acknowledgement of the work of Dewey.

Table 3-2 Linking Dewey's model of inquiry to this research study

Stage	Dewey's systematic approach to inquiry (Morgan, 2014 p.1047)	Rational/design in this research project
1	Recognising a situation as problematic	Outreach programmes in science are used as a tool to enthuse and further engage groups of learners in science (e.g., those from a lower socioeconomic background). There has been little consideration in the literature of how the design of these programmes are equipped to do this.
2	Considering the difference, it makes to define the problem one way rather than another	This problem is linked to the design of outreach programmes as the key to being able to engage and enthuse specific groups of learners. This is rather than focusing on the views of different learners who experience these programmes and the impact it may have on the individual.
3	Developing a possible line of action as a response to the problem	Collecting primary data from teachers to find out what they feel the impact is on their students who experience outreach activities in science. Ask teachers to share what they think works/or does not work in science outreach activities.
4	Evaluating potential actions in terms of their likely consequences	Use the primary data to create a model that seeks the 'optimum' design of science outreach programmes to ensure sustainable impact. Use teacher focus groups to refine the model further.
5	Taking actions that are felt to be likely to address the problematic situation	Share and publish the science outreach model for sustainable impact, to allow key stakeholders (policymakers, outreach providers and schools) to consider the recommendations.

3.2 MIXED METHOD RESEARCH (MMR)

It has been discussed how Kuhn (1970) challenged and shifted the idea of some of the more traditional paradigms in science (Section 3.1); however, in science education research it is necessary to negotiate input from several academic fields which can make this tricky (Schulz, 2014). Borrego, Douglas and Amelink (2009) suggests that no research method (including mixed) should be more privileged, as its worth will derive from the desire to answer the research question. This section explores how and why this research study utilises both quantitative and qualitative approaches resulting in a mixed method approach.

3.2.1 A 'PARADIGM WAR.'

Quantitative and qualitative research methods dominate the human and social sciences as these paradigms seek answers for social phenomenon (Smith, 2018). Many researchers' world views, result in them adopting a mono-method approach whereby there is a purist stance to choosing either a quantitative or qualitative approach to inquiry. However, as a pragmatist this purist approach is not necessary or advocated as Smith (2018) explains how understanding the social phenomenon is more important than selecting a single research data collection philosophy. Onwuegbuzie & Leech (2005) describe how researchers who use a pragmatic approach can utilise the strengths of both a quantitative and qualitative approach to truly answer the research questions. Thus, clarification of the key differences between these two research methodologies is considered here.

Common types of quantitative research involve data collection via experiments or surveys (Smith, 2018). Quantitative research methods suit research problems that aim to deduce, hypothesise or theories justify variables (Borrego et al, 2009); drawing conclusions from data collected and measures of statistical analysis (Creswell, 2002). This approach is usually associated with positivist researchers who wish to explore the cause and effect of phenomenon as pure quantitative methodologies are objective in nature (Smith, 2018). This contrasts with qualitative research, which was viewed as a "countermovement to the positive paradigm" and is adopted by constructivists and naturalists (Smith, 2018, p.2). The qualitative research approach uses a more inductive process, as the research process is determined by the views of the subjects. Whilst it is described how the results to these qualitative studies are more subjective, this does not mean that this type of research is 'easier' as Borrego et al (2009) suggests, it just comes with a different set of approaches to obtaining and analysis data. Common qualitative research designs found in the social sciences are ethnographic studies, Grounded Theory, Case studies and Phenomenological studies, which involved the researchers' exploring human experience via observations, multiple stage data collections, exploring phenomena over time and using detailed descriptions (Creswell, 2002; Smith 2018)

Considering the strengths and limitations of different approaches is important to ensure the most appropriate methods are chosen for the data collection to enable the research questions to be answered (Bamkin, Maynard and Goulding, 2016). Bamkin et al (2016), argued that some studies using a single methodology will not provide a balanced conclusion and therefore, using several methodologies is necessary to satisfy a research question. Denscombe (2008), developed this notion further by suggesting that mixed methods research (MMR) can not only increase the accuracy of the data collected, but can provide a much more complete overview of a phenomenon. This is because the research methodology utilises the quantitative data to address 'what' may be occurring and the qualitative data to explore the 'how' or 'why' research questions (Cohen et al., 2018). Ercikan and Roth (2006), dislike the tendency to place research solely into either category, thus, supporting the principles of MMR. While these statements highlight reasons why MMR has increased since the 1980s, there remains those who oppose this approach. These centre around two critiques; 'The embedded methods argument' based on the ideas that certain methods are linked to certain epistemologies, and 'The paradigm argument' which is that qualitative and quantitative research are viewed as separate paradigms (Bryman, 2016, p.636).

Both arguments refuting mixed methods research, reflect the idea that research tools or approaches are inextricably linked with concrete epistemological and ontological commitments. For example, an individual who aims to conduct both a closed questionnaire (Quantitative) and an in-depth interview (Qualitative) to collect data regarding a particular research question cannot just combine the responses, as it is viewed that the epistemological positions of these methods are cemented in two different views of how social reality should be constructed (Bryman, 2016). This argument also relates to that of the paradigm argument (Section 3.1); paradigms are clusters of beliefs that are embedded in values, methods, and assumptions. Tashakkori and Teddlie (1998), considered how these paradigms can represent opposite views of the world and how encompassing a particular paradigm can guide a researcher regarding their design and approach to a research problem. Challenging these worldviews and use of mono-methods, are referred to as the 'paradigm wars' (Tashakkori and Teddlie, 1998). The 'wars' debate the link between paradigm and methodology; whilst some theorists view different paradigm incommensurable as the differences between them are irreconcilable, other theorists view paradigms, and their exclusive methods, are overplayed terms (Armitage, 2007).

Johnson and Onwuegbuzie (2004, p.14) advocated in the title of their research that "mixed methods research is 'a research paradigm whose time has come'"; as this 'best fit' approach allows the research focus to be centred upon the design and methodology being fit for practice, as opposed to the approach being reliant on a philosophical stance (Darlington & Scott, 2002). This approach aligns more with the 'technical version' surrounding the debate between quantitative and qualitative research, as it views these two research strategies as compatible (Bryman, 2016). Creswell (2002) describes how pragmatists focus upon the nature and purpose of the research to determine the choice of the approach as some research questions do not perfectly sit with either quantitative or qualitative methodologies. This project used a pragmatist and mixed methods approach to design a sustainable model for science outreach programmes by utilising the strengths of the different methodologies to accumulate and use the data. Thus, being to answer the research questions as different frameworks were drawn-upon at different stages to generate a variety of quantitative and qualitative data.

3.2.2 Design of the mixed-methods research project

Mixed methodologies do not merely use two types of data sets on a single research question; it is a paradigm in which both types of data will be mutually insightful (Bryman, 2016). Greene (2008) recommends that priority should be set for the balance between quantitative or qualitative data collected, and in line with their suggestions this research study undertook a heightened qualitative approach, as quantitative data was collected only during Phase One of the study. The design of this MMR project is split into two phases; the first phase contains two studies, and the second phase contains one study. Overall, this would be identified as a multi-phase/iterative mixed method design as presented in Figure 3-2 (Creswell and Plano Clark, 2011). The first study in Phase One utilised the embedded design, as provided by Creswell and Plano Clark (2011), which arises when the researcher feels that choosing a singular approach, may limit the findings for the research question. This first study then informs the next stages of data collection which adopts the multi-phase design.

As a mixed-methods approach would be beneficial to collect data to answer the research questions, this supports the pragmatist approach; thus, there needs to be a stage in which the findings from the combined methods are viewed holistically. The two proposed phases use different methods, and each data collection point will inform the construction of the 'optimum' sustainable model of science outreach. The design, therefore, allowed there to be natural triangulation points in which the data was reviewed to either draft the model or to present the final model (Denzin, 2012). See Figure 3-2 for further clarity.

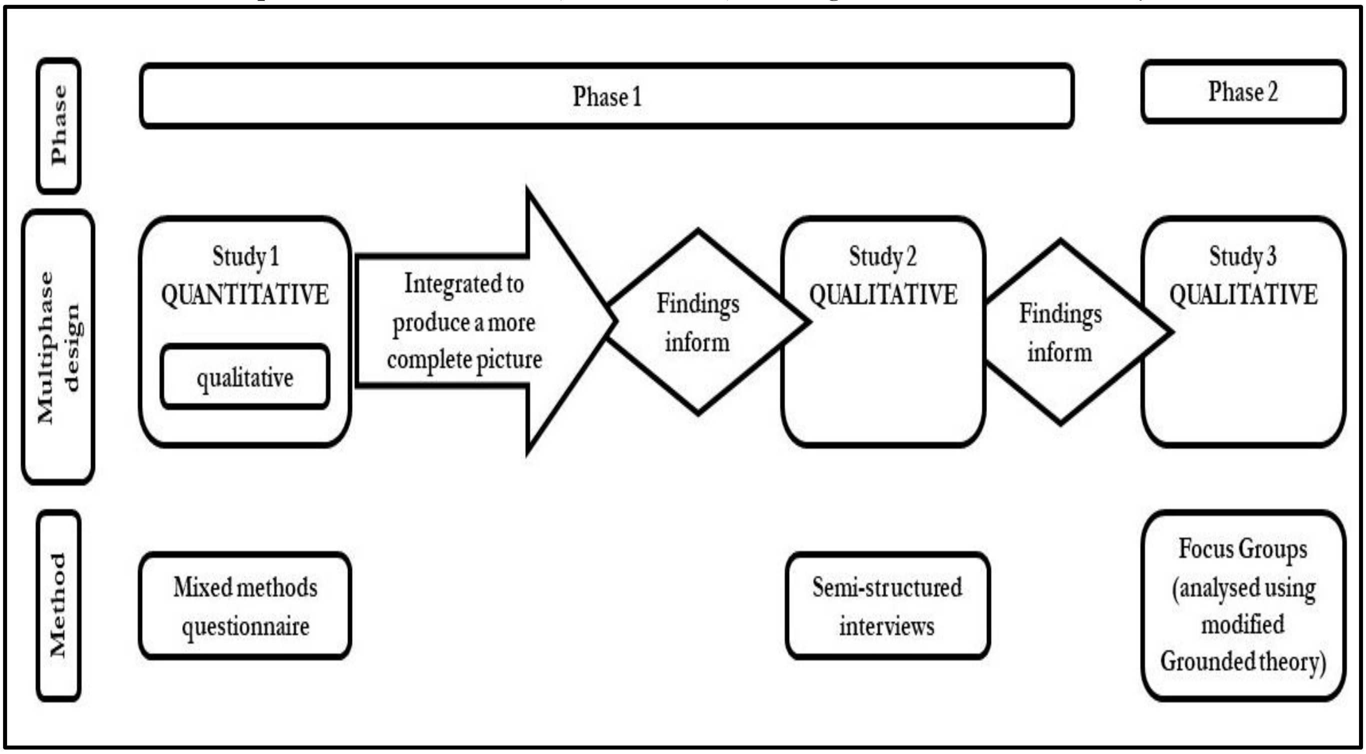


Figure 3-2 Mixed Method Design of the overall research project

3.2.3 The inductive and deductive theory

It is also important for the researcher to consider how they wish to analyse the data; this is often linked to deductive or inductive models whereby the relationship between theory and research are explored (Blackie, 2007). During the deductive process the researcher draws upon existing theories and primary data to confirm or refine the hypothesis. The inductive process is opposite by utilising observations, the findings of which inform the theory (Blackie, 2007). Cohen et al (2018) outlined the historical view for each approach from describing Aristotle's contribution to forming logic as deductive reasoning by explaining how this was known at the time as 'syllogism', which is a form of reasoning whereby a conclusion can be drawn from different propositions or premises.

It was in the 1660s that Francis Bacon became increasingly critical of the deductive approach and emphasised the uses of observations of a number of cases could be used to form a hypothesis. This led to the formation of the inductive-deductive approach which combines the two, whereby hypotheses can be formed and revised (Cohen et al, 2018). Bryrman (2012) similarly describes how there are many instances where research does not just simply adapt to one approach; for even in the inductive stage, it is not always possible that the hypotheses are clear and final (Bryman, 2012). Thus, Bryman (2012) describes how a researcher may move between the deductive and inductive approach creating a 'wave effect'. This new strategy is called 'iterative', as it allows the researcher to 'wave' back and forth between the data and the theory.

Phase One of this research study, used a deductive approach to generate information regarding teachers' perceptions of science outreach work in schools. During Phase Two of the study, an inductive approach was taken whereby modified principles of Grounded Theory (GT) were utilised in order to analyse focus groups, generating data which allowed an optimum model of science outreach work in schools to be proposed. GT evidences this iterative strategy and therefore, becomes an important framework when attempting to construct a new and unique model, at this stage in the research study. This combination of different methodologies lends itself to the 'mixed methods' approach. LeCompte and Preissle (1993, p.232) describe this approach to be multimodal, making the researcher a "methodological Omnivore".

3.3 SAMPLE SELECTIONS

Tto ensure that the timescale was realistic for this doctoral study and without risking the integrity of the project itself, it was decided that data collection should be centred upon teachers in the North West of England. The reasons for the data sample to come from this area of the UK not only reflects the geographical location of the researcher but also, the desire to sustain a STEM workforce in the area. In 2015, during the final months of the coalition government in the UK, the then Prime Minister, David Cameron, and his Chancellor, George Osborne, dictated a 6-point long-term economic plan for the North West (NW) of England (HM Treasury, 2015). Their fourth point aimed to '…make the north-west a global centre of outstanding scientific innovation…with major investments in the excellent universities …'. This focus is still prominent as the 'N8 research partnership', a three-year strategy involving eight research institutes in the north of England, aims to promote collaboration, innovation, and drive the economy (N8, 2017).

The N8 research strategy outlines how Science and Innovation Audits will deepen understanding of the region's potential by examining key strengths to provide evidence of their potential to build and develop world-leading products, services and technologies. Lee (2017) discusses how in the NW, there is a clear focus upon medical, energy, biotechnology industries, chemical processing and advanced materials. However, if this strategy is to succeed and the NW is to become a centre of scientific excellence, then a key to this will be in the recruitment of future scientists (N8, 2017). By focussing this study upon science outreach work in this area of England, it may influence learners to study science post-16. Thus, securing future scientists to occupy these roles and drive the scientific industry forward in the UK.

Thus, the focus of this study was to collate primary data from a questionnaire with teachers regarding their perceptions of science outreach programmes. According to Gorard and See (2009), there is a particular focus on outreach work being used as an intervention tool to reduce the gap in attainment between pupils of different socioeconomic status. Therefore, this research study aimed to critically investigate the views of teachers in the North-West of England regarding science-based outreach programmes, especially in the context of children's social demography.

3.4 PHASE ONE: PROCEDURE OF DATA COLLECTION AND ANALYSIS

This first phase contained two distinct studies; a questionnaire that generated quantitative and qualitative data and individual face-to-face semi-structured interviews. This next section outlines the aims, rationale and design of each study and an outline of the participants recruited for each stage. An account of the data analysis and ethical procedures are also considered.

3.4.1 STAGE 1: A MIXED METHODS QUESTIONNAIRE

1.1.1.1 Objectives

i. Explore teachers' perceptions regarding science outreach programmes, which operate in a range of different school settings and environments.
ii. Identify if teachers are engaging with science outreach activities in the North West of England.

3.4.1.1 Rationale

Gillham (2008) proposes that questionnaires are useful for collecting straightforward information, in addition to being a useful tool to draw conclusions from a population (Davies, 2007). As this is the first study of the research it was beneficial to use a technique which participants are already familiar with, as people are more likely to participate as they know what is expected of them. Questionnaires are encountered on a regular basis from a passport form, job application, or even the council asking for opinions about a new development (Davies, 2007). Thus, Greener (2011, p.38) recognised questionnaires as "almost the common-sense approach to doing social research". However, to ensure the success of this type of data collection, Cohen et al (2018) suggests that it is essential that the questionnaire has a clear objective and that the design of the questions anticipates the type of data collected. In terms of this study, this is achieved by having clear objectives (which are outlined at the start of this section) and utilising a mixed-methods questionnaire. The detail of the types of questions and why they were chosen is discussed in the next section.

3.4.2 DESIGN

This section outlines the design of the original questionnaire and justifies the questions utilised with reasoning for the chosen methods of analysis adopted. The questions themselves were centred upon discussions presented within chapter 2 and were formulated to find out more information about teacher's views of science outreach programmes in the context of; SES, gender and age in particular. A copy of the questionnaire used within this doctoral study can be found in Appendix E: Example of completed questionnaire on paper and online.

3.4.2.1 Questioning

There are several types of question that can be used within a questionnaire; the type of responses generated that determine these. For example, Cohen et al (2018) explain how closed questions will often mean the respondent has a predetermined range of a possible outcome (i.e., yes or no responses). Whereas open-ended questions invite honest and personal comments that are indicated by an unstructured space for the respondent to reply. Greener (2011) outlined the advantages and disadvantages of using open and closed questions within a questionnaire; closed questions reduce ambiguity (the researcher needs to have a firm understanding of the possible responses to the questions) whereas, open questions allow the participant to respond freely and helps to remove a possible researcher bias (although these questions may be missed or rushed during the data collection process, as they take more time). Therefore, the researcher decided to incorporate both types of questions to provide a variety of responses; thus, utilising both quantitative and qualitative approaches. Cohen et al (2018), stipulated that it is vital to plan the questions with the data analysis in mind. As this mixed methods questionnaire had a QUAN+qual balance, there were all but two questions which presented multiple-choice questions using a Likert scale (Likert, 1932).

3.4.2.2 Open-ended questions

Although there are only two-open ended questions (see Section 3.4.2.2), they presented an opportunity for the participants to share their own personal views and experiences of science outreach programmes. Cohen et al (2018) discuss how creating these opportunities for participants to provide a free response can often generate rich and authentic information that may not have been captured otherwise. Whilst one would consider why all surveys do not contain these types of questions, there are limitations with open-ended questions. Firstly, being able to generate an effective open-ended question is difficult as seemingly some of these that are designed to generate honesty may be quite leading (Gershon, 2013). Secondly, open-ended questions are more troublesome when it comes to data handling and can result in 'data overload' (Cohen et al, 2018, p.475). It is often a struggle in converting this data; if the focus is "quantitating qualitative data" then it is questionable whether the question should have been an open-ended question in the first place. Thus, in the first data collection method it was decided to only include two open response questions to enrich the closed data collected, and to ensure that the data analysis was manageable in the given timeframe and scope of this doctoral research study.

3.4.2.3 Closed questions

Within this questionnaire, there are three modes of delivering closed questions that informed the qualitative methods that are also employed in this research, these were either the use of dichotomous questions, multiple choice or demographic questions (Krosnick & Presser, 2010). The advantages of these types of questions are that closed questions code relatively easily and multiple-choice questions provide responses that have little room for biased interpretation by the researcher (De Vaus, 2013). For example, the multiple-choice questions provided discrete data that do not overlap, whereas dichotomous questions are different as they usually require a yes or no answer and this compels the respondent to answer on a particular issue and not to 'sit on the fence' (Cohen et al, 2018).

These types of question were used to capture information regarding the participant and whether or not they had been engaged with science outreach programmes previously.

The demographic questions asked participants about their professional careers and their employing school during the data collection period (see Table 3-3 for a breakdown of the question types). In this study, these types of questions are insightful as if several participants identified that science outreach programmes were not important at the primary school level, demographics data can add depth and an element of comparison to the discussion (Krosnick & Presser, 2010).

Table 3-3 A sample of some closed questions used within the questionnaire

Closed-questions	**Response**	**Type of Q**
(1) Please indicate the educational level(s) or science you teach:	KS1/KS2/KS3/KS4/KS5	Dichotomous
(3) Please indicate what you consider to be part of science outreach programmes:	Science-STEM clubs/visits to universities/science fairs/ extra homework/ placements/ science competitions/ science shows/links with local industry/ extension work in science/ guest speakers/ science careers day/ other	Multiple-choice
(7) Please identify any outreach programmes which currently operate in your school:	Partnership with a university/ partnership with other school(s)/ science-STEM clubs/science careers fairs-advise-talks/ trips to science fairs-shows/ links with other businesses-outside industry/ out of hours science sessions/other/none	Multiple-choice
(8) Considering all science outreach programmes which occur, on average please identify how frequently these types of activities occur:	Once or twice a year/ once a term/ once a half-term/ every 2-3 weeks-every week-never No	Multiple-choice
(9a) Gender	Male/ female/ other/ prefer not to say	Demographic
(9bi) Which type of institute do you currently teach in?	Primary school/ middle school/ secondary school/ secondary school with a sixth form/ All through school (3-16 or 3-18)/ 6th form centre or college.	Demographic
(9bii) Which type of institute do you currently teach in?	State-funded/ independent school/ academy/ free school/ other	Demographic
(9c) How long have you been qualified as a teacher?	Less than a year/ 1 or 2 years/ 3 or 4 years/ 5 or above years but less than 10/10 or above years but less than 20/ 20 or above years.	Demographic
(9d) How long have you been teaching?	Less than a year/ 1 or 2 years/ 3 or 4 years/ 5 or above years but less than 10/10 or above years but less than 20/ 20 or above years.	Demographic
(10) Are you happy to be contacted about being involved in further research in this area?	Yes/ no	Dichotomous

3.4.2.4 Likert Scales

Likert scale questions are also closed questions and according to Cohen et al (2018), are (a.) widely used in research and (b.) are used to understand attitudes, feelings and belief of a population (c). The use of the Likert scale allows the respondent to answer a question using a 'rating scale' as it allows the collation of discrete data to accommodate the degree in which someone may agree or disagree (Champagne, 2014). Cohen et al (2018) describe the benefits of the Likert scale, as this delivery of questioning means that responses also build in a degree of sensitivity and differentiation, whilst also still generating numbers. However, it is important to ensure that when using this style of questioning, only one factor is being measured as this is pinnacle to Likert's design of this scale and the nature of a closed question (Likert, 1932). It is also important to consider the number of scale points within the design of the question and how these are labelled as this can impact on the data that is generated (Champagne, 2014). Freidman and Amoo (1999) advocate the use of a five-to-eleven-point scale. The researcher chose a five-point scale for this questionnaire due to it still being an odd number and the labels deemed appropriate when asking opinions of the teachers (see Appendix E: Example of completed questionnaire on paper and online for an example of these).

Cohen et al (2018) considered limitations of using a Likert Scale such as; the assumption that there may be equal intervals between the categories, the fact that numbers may have different meanings for different individuals, and that some scales may be skewed towards one 'opinion' and thus induce a biased response. Youngman (1984) outlines some participants are wary regarding 'extreme' statements, for example, 'strongly agree' or 'strongly disagree', as this implies total assurance, and they may feel that this does not represent their exact opinions. The scale itself may be problematic, as the options presented to the respondent may not represent their exact thoughts and feelings. Cohen et al (2018) suggest there are less-obvious issues too, such as the western world is biased towards the left-hand side of a scale and the respondent may not be telling the truth. Thus, when considering the design of the questionnaire itself the layout and the scales will try to address limitations; for example, the scale was presented as a list vertically rather than horizontally (reducing the bias towards the left-hand side of a scale). Another pitfall of the sole use of the Likert scale is respondents cannot add comments regarding the issues being explored (Cohen et al, 2018). Thus, the inclusion of two 'open questions', will encourage the participant to provide a freely written response will eliminate this criticism; only including two will consider 'respondent fatigue' too (Bryman, 2012).

3.4.2.5 Test for internal reliability

As the design of this questionnaire was unique and had been informed form a comprehensive literature review, thus it had not been pre-validated by other research studies. Hyman, Lamb and Bulmer (2006) discussed how pre-existing questions/surveys are a useful data source as they have been extensively tested during their first use. Bryman (2012) confirms that with pre-existing surveys the data generated previously in the study is a reliable source. Whilst the consideration of using a pre-existing questionnaire was contemplated, there were no pre-validated surveys that would allow the research questions to be answered. Therefore, an original questionnaire was designed and informed by the literature review. To measure internal reliability, the Cronbach alpha test has been applied to question 4 and 5 (see Table 3-4) which uses the multiple indicator measures (Likert Scale, 1932). Internal reliability considers the coherence of questions which are grouped and whereby their responses may be aggregated (Bryman, 2012). This is important, as if questions are incoherent then this indicates that the items in this question are unrelated. Upon analysing the data, any differences perceived (a *p*-value, which can determine statistical significance) may in fact not be related at all in the first place, known as a type 2 error. Following the Cronbach alpha test, the scores for these questions were 0.821 and 0.833 respectively, which indicates an acceptable level of internal reliability; Bryman (2012) indicates that a value above 0.70 is considered to be satisfactory. Two questions provided the opportunity for participants to answer freely and the remaining questions were multiple choice (Likert Scale, 1932). These open response questions were not 'grouped', they did not require the Cronbach alpha test for reliability of data produced.

Table 3-4 Question 4 and Question 5

Question Number	Likert Scale	Question	Cronbach Alpha value
4	Regardless of the current level which you teach, please complete the following by placing a tick in **one space** only as follows: *1=Not at all, 2=very little 3=a little, 4= quite a lot 5=a great deal*	How important do you consider science outreach work to be at primary school level?	0.821
		How important do you consider science/chemistry outreach work to be at secondary school level?	
		How important do you consider chemistry outreach work to be at sixth form/college level?	
		How important do you consider science/chemistry outreach work to be for girls?	
		How important do you consider science/chemistry outreach work to be for boys?	
		How important do you consider science/chemistry outreach work to be for pupil premium students?	
5	Please indicate how you feel about the following statements by placing a tick in **one space** only as follows: *1=strongly disagree, 2=disagree 3=neither disagree or agree, 4= agree, 5=strongly agree*	"Outreach work in science/chemistry helps to enhance pupils learning in their everyday science lessons."	0.833
		"Science/chemistry outreach work inspires students to consider science careers they may not otherwise have thought about"	
		"Pupils who are involved in science/chemistry outreach programmes are more likely to enjoy science."	
		"Science/chemistry outreach work has a lasting impact on students involved within the programme."	
		"Science/chemistry outreach work enriches the science programmes of study within my school/college."	
		"Outreach programmes in science/chemistry allow pupils to experience activities they may otherwise not have the opportunities to do so."	
		"Science/chemistry outreach work motivates students to apply to science courses at university."	
		"Science/chemistry outreach programmes are valued as an intervention tool within schools/colleges to raise attainment in science."	

3.4.2.6 How to collect the best quantity and quality of data

Greener (2011) expressed how despite their widespread use, questionnaires are often executed poorly. Therefore, a pre-pilot study was conducted with doctoral students of the School of Education at LJMU (*n*=5) who completed the questionnaire to ensure that the language within the proposed questions were not ambiguous or non-essential (Davies, 2007). Cohen et al, (2018) described this as a practice that aims to increase reliability, validity, and practicability of questionnaires. In this instance, the participants were able to identify any omissions or issues with readability; they also provided feedback regarding each question to ensure they were understandable and that the layout and the length of the questionnaire was appropriate. A pilot study was then undertaken with a local secondary school's science department ((paper copies (*n*=12); online questionnaire (*n*=3)) The pilot study aimed to assist with the quality assurance of the questionnaire itself by collecting data from a like community that would be involved in the main study. Following small revisions from the pilot group (outlined in chapter 4.1.1), the questionnaire was sent to a sample of schools within the Northwest of England (see section 3.4.3 for selection criteria).

It was decided to primarily use a paper version of the questionnaire to increase the chance of successful returns as Cohen et al (2018) suggest response rates are higher, although, Tepper-Jacob (2011) describes the cost benefits of web-based questionnaires; it was suggested that the cost savings here were not enough sufficient to offset the potential loss of sample, due to clerical web-based errors, or lower response rates. While response rates are the main focus in this stage of the project, it was worth noting that Wolfe et al. (2008) did not find that paper-based questionnaires increased the response rate in terms of the number of questionnaires returned.

Considering the benefits and limitations of both modes of delivery of this research activity; selected schools were sent paper versions that contained a web link and QR code, linked to a web-based version of the questionnaire. As a further incentive to encourage more questionnaires to be returned, a self-addressed postage paid envelope was included within the information sent to selected schools (see next section below); Cohen et al (2018) outlined this as good practise when sending out postal interviews and Schilpzand et al (2015) suggest incentives (such as this) can increase the response rate. Thus, it was anticipated that this sacrifice of the cost would be beneficial in terms of gathering teachers' knowledge and by offering a choice of completion (Bryman, 2012).

3.4.3 Participants

In 2016 (when this data collection aspect of the study was undertaken), in the 23 Local Authorities (LA) in the North West of England, there were approximately 2198 primary schools, 455 secondary schools and 67 further education (FE) colleges as highlighted in Appendix C: Data table of schools in the NW of England. For data to be collected from across the region, a stratified sample of schools in randomly selected authorities were sent the questionnaires; this type of sampling allows the whole population to be split into sub-groups (namely strata) and then a sample randomly selected from this (Cohen et al, 2018) .

Gillham (2008) described how stratified sampling will ensure that within each sub-group, in this case, educational school level (e.g. Primary, Secondary…), will be fairly represented despite the percentages sampled in each group being different. This practice allows a researcher to draw conclusions on the 'larger' population, though Davies (2007) highlighted that in any research exercise, the researcher must be rigorous and honest with their sampling techniques which allow (or not allow) findings to be generalised. Therefore, it is important that the data in this study was representative of science outreach programmes within the NW of England, then schools from different regions within the NW need to be included in the sample. By drawing on the principles of stratified random sampling, it ensured that there was an element of randomness (which aims to reduce bias), whilst safeguarding the views of each subgroup (e.g. LA) are present in the data collected (Davies, 2007).

Cohen et al (2018) outline how to collect the appropriate sample size and suggest that there is no simple answer here. Generally, for quantitative research, the larger the sample size the better, however thirty responses would be a minimum number for statistical tests to be performed. Thus, when considering the appropriate sample size, consideration needs to be made as to whether the data can be analysed accurately and meets the assumptions of the statistical tests selected. The same is true when it comes to sample size and the chosen methods; for example, when using surveys, a larger sample is required compared to using an ethnographic approach whereby sample sizes are smaller but data is a lot more descriptive in volume (Cohen et al, 2018).

In this study, the main issue is that there were a large number of schools in the NW of England, and it was simply not viable to use the total population when applying the sample size formula (Macorr Research Solutions Online, 2016) It would not be economically viable, as Gillham (2008) highlights that the costs of surveying an entire 'population' would be astronomical, thus, a random sample of participants is adequate.

Cohen et al (2018, p.205) describe how the size of a random sample may be determined "by the researcher exercising prudence and ensuring that the sample represents the wider features of the population". Thus, the researcher decided to randomly select six of the 23 local authorities as this represented 25% of the initial population, which was considered to be a reasonable percentage to manage in terms of time and funding constraints of the doctoral study.

Table 3-5 represents the number of schools present in each county (from the selected sample) and the educational institutes within each area. From this, 25% of each type of school were sent questionnaires; primary schools and FE colleges will receive five copies of the questionnaire and secondary schools will be sent ten. This was to represent that there is usually a large science department at secondary schools. The information included with the printed questionnaires also indicated that these could be copied for additional participants. To identify each school, they were allocated a number based on the alphabetical list; these numbers were selected using a random number generator (random.org, n.d) Thus, the total number of paper copies of the questionnaire sent to teachers was 1,005.

Table 3-5 Sample size calculations of school LA to be sent a questionnaire. * Indicated that the number was less than 1, but 1 is the smallest value allowed in each sub-group

County	LAs included	Total primary schools	25% sample size	No of surveys (x5)	Total Secondary schools	25% sample size	No of surveys (x10)	Total FE Institutes	25% sample size	No of surveys (x5)
Cheshire	Cheshire West and Chester	142	36	180	19	5	50	3	1	5
Greater Manchester	Rochdale	66	17	85	12	3	30	2	1	5
	Tameside	75	19	95	15	4	40	3	1	5
Lancashire	Warrington	69	17	85	13	3	30	2	1	5
Merseyside	Liverpool	135	34	170	31	8	80	1	1*	5
Cumbria	Cumbria	30	8	40	37	9	90	5	1	5
TOTAL		517	131	655	127	32	320	16	6	30

3.4.4 Data analysis of the mixed-methods questionnaire

Paper copies of the questionnaire, along with the access to the web-based version, were distributed to the sample outlined in the previous section. Data was collected during a five-month period, which was the maximum amount of time available for the researcher to collect the participant responses to allow the analysis from the data to inform Phase Two of the research study. After this period the questionnaires were analysed using different modes to complement the mixed methods approach. Standard statistical tests were used to explore the quantitative data (see section 3.4.4.1) and thematic analysis was used to depict themes from the open questions. To be able to analyse the data, it is important to have a clear understanding of the data sets. For example, Likert Scale questions generate data that can be ranked, as they provide an ordinal level of measurement. In contrast, multiple-choice questions are nominal levels of measurement and favour the expression of frequencies due to their discrete categories (Check and Schutt, 2012). Thus, according to Denscombe (2010), understanding the data sets is an important stage to be able to successfully analyse the data.

To be able to analyse the responses, the data needs to be transformed from tick boxes and paragraphs to a comparable form. Denscombe (2010) describes how this is achieved by 'coding' the raw data, by allocating numbers to the data. And it is advised that with quantitative data (closed questions), this is completed prior to the data collection. For the qualitative data, the coding process differs; the initial deductive approach allows for pre-determined codes from the literature, but then during the thematic analyse of the data, new codes were generated (see the description of this process in 3.4.4.2).

To further organise the raw data, codes were applied to the responses (Appendix F: Phase One coding frame and codebook), and a master data set was kept in a password protected Excel file. The researcher selected the IBM Statistical Package for the Social Sciences v25 (SPSS) (IBM Corp, 2017) for the analysis of the quantitative data (see an example of this in Appendix O: SPSS worked examples regarding the importance of science outreach at different educations levels) and to assist with the qualitative analysis NVivo V11 (QSR International Pty Ltd, 2017) was the chosen software package (see an example in Appendix P: NVivo stage 1 and 2 examples of working). Both these packages are frequently used in the social sciences and are described by Davies (2007) as powerful tools to assist with the analysis of this type of data. However, it is advised in both cases that the researcher is trained in how to use the software effectively in order to save time. The packages need to be tailored to support the data sets; for the SPSS package, the researcher manually inputted the variable names behind the numerical identifiers, and in NVivo, the data was sorted into codes, which were then manually placed into themes.

Before interpreting the results, it is important to ensure that the data is validated. Denscombe (2010, p.267) suggests that this can be achieved by ensuring that:

> The data has been recorded accurately and precisely. The data is appropriate for the purposes of the investigation (we must feel assured that we measure the right thing) and the explanation derived from the analysis is correct.

This was achieved by checking for human error during the input stages by asking a peer to double check figures and also carrying out statistical tests on the internal reliability (see previous section 3.4.2.5) and piloting the questionnaire to ensure the responses match the research aims. Denscombe (2010) outlined several ways to check that results are valid; for example, different researchers would present similar findings from the same data set. In this study, this was achieved by asking a colleague to sample 20% (*n*=10) of the questionnaires to ensure that they agreed with the coding process and that they arrived at similar results, especially when analysing the open questions. This is known as inter-rater consistency (Carmines and Zeller, 1979)

3.4.4.1 Quantitative analysis of the closed questions

The quantitative analysis process allows a way to be able to interpret quantities of data quickly. Additionally, quantitative analysis can provide the researcher with confidence with their interpretation of the data and statistical significance allows values to be compared and contrasted (Denscombe, 2010). These reported values align with a more objective approach whereby data is considered to be accurate, valid and reliable (Smith, 2018). However, the researcher still makes choices and uses their discretion throughout the process which may influence findings and result in bias (Denscombe, 2010).

In this study, the statistical tests used are explained below and are summarised in Table 3-6. These tests aimed to depict teachers' views of the importance of outreach activities for different groups of pupils and their perceptions of science outreach programmes. The descriptive statistics reviewed the pilot data and these results, along with comments from the open questions were used to generate null hypotheses. These were then accepted or rejected based on further testing.

Table 3-6 A summary of quantitative statistical tests used in study 1

Quantitative tool	Purpose	Implications for Study 1
Descriptive statistics (Davis, 2013)	Descriptive statistics can uncover information about quantities and the shape of the data; whilst it does not provide inferential statistics it is often deemed as an important preliminary stage before using other statistical tests (Davis, 2013).	In this study, descriptive statistics were used to represent the percentage of the population and in calculating the mean for different data sets.
Test for normality (Shapiro and Wilk, 1965)	Data sets show correlations that exist as they represent the relationship between the data. There are two tests used to test for normality; either the Shapiro-Wilk test or the Kolmogorov-Smirnov test (Laerd Statistics, 2018). Both provide a means of testing the distribution of the data, but the Shapiro-Wilk test was chosen as it is more accurate with smaller sample sizes (Shapiro-Wilk, 1965).	This test indicated that the data was mostly non-parametric. This means that the data is skewed (Davis, 2013).
Mann-Whitney U Test (Mann and Whitney, 1947)	This is a non-parametric test which examines the differences between two different populations against an ordinal/ranked scale (Laerd statistics, 2018).	This test was used to determine if the opinions of the participants were linked to whether they taught at a primary school or secondary school or above.
Kruskal Wallis (Kruskal and Wallis, 1952)	This is a non-parametric test that is used to compare differences between groups when there are more than two conditions. This test allows post-hoc testing to be able to interpret the data in more depth (Davis, 2013).	This test was used to determine if the opinions of those in previous questions had an impact on how they answered other questions that were to do with the impact of science outreach activities on pupils from a lower socio-economic background.
Friedmans (Friedman, 1937)	This is a non-parametric test which aims to find out the difference between mean scores with the same population in different conditions.	It was used as a way to determine if the null hypothesis regarding the importance of science outreach activities at different educational levels could be accepted or rejected.
Wilcoxon Signed Rank test (Wilcoxon, 1945)	This is a non-parametric post-hoc test which determines if there is a significance between the same groups of participants under two different conditions (Davis, 2013).	The test indicated between which school levels teachers' perceived science outreach programmes to be of greatest importance.
Bonferroni adjustment (Bonferroni, 1936)	This post-hoc test technique is applied to reduce the chance of a type 1 error. It adjusts the alpha value (significance level) to account for the number of comparisons to ensure values remain significant and are not due to chance (Dunn, 1964: Pallant, 2013).	It ensured that the acceptance and rejection of the null hypothesis were correct.

When reporting the results in Chapter 4, they were formatted in the following manner to make it explicit as to which variables were being compared; therefore, it is clear as to whether the null hypothesis could be accepted or rejected based on what value is being measure (see section 3.4.4.1.1 for the details of the test described below). An example of the structure to present these quantitative results is shown below and is based on recommendations from Laerd (2019):

Example of Mann-Whitney U in text (Laerd Statistics, 2018):

> A Mann-Whitney U test was run to determine if there were differences in [Likert scale question] score between [Variable a] and [Variable b]. Distributions of the [Likert] scores for [Variable a] and [Variable b] were [either similar or not similar], as assessed by visual inspection. [Likert] scores for [Variable a] (mean rank = *) [were/not] statistically significantly [higher/lower] than for [variable b] (mean rank = *), *U* [Mann-Whitney U score] = *, *z* [standardised test statistic] = *, *p* [significance level] = **.

3.4.4.1.1 Descriptive statistics and test for normality

One of the first exercises that should be carried out on the data set is descriptive statistics (Davis, 2013). This stage does not just present basic interpretations of the data; it also allows any missing data to be highlighted and assesses the normality of the data (Pallant, 2013). Normal (parametric) data is associated with a 'bell-shaped' curve, whereas non-normal (non-parametric) data may present extremes in the data towards small or large scores resulting in skewed data (Davis, 2013). Assessing normality is important when it comes to discovering which statistical tests to apply to the data. For example, parametric tests will make assumptions about the distribution of the data, but non-parametric tests will ignore the skewed nature of the data (Davis, 2013). Therefore, non-parametric tests can be used on parametric data, but not vice-versa. This does pose its disadvantages to the dataset as non-parametric statistics are deemed to be "less sensitive than their more powerful parametric cousins and may fail to detect differences between groups that actually exist" (Pallant, 2013 p.221). However, whilst this may be the case, when it comes to ordinal or ranked data (using the Likert scale), non-parametric tests are ideal along as they are useful with smaller samples; this reflects Phase One, Study 1.

The advantages of using basic descriptive statistics analysis is that they are easy to calculate and can result in quality findings, as opposed to terms 'many participants' and 'most participants indicated that' (Greener, 2011). The frequency, mean, mode, median and standard deviation are easily obtained using descriptive tests in the SPSS packages. Carrying out these tests allow the researcher to see a 'broader picture' of the data set, and plan how they wish to explore the findings in greater depth. In this study, the descriptive tests provided specific information regarding teachers' general views of science outreach programmes.

3.4.4.1.2 Spearman's Rank Correlation Coefficient

This statistical test allows the researcher to measure differences and thus the relationship between particular variables (Davis, 2013); described by Field (2013) as a *bivariate correlation*. This is the correlation coefficient (r_s), which can be positive, negative or completely random (i.e. no correlation). To place a value on this, this statistic can range from -1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 having absolutely no correlation. This is a non-parametric test that is known as Spearman's rho (r); it ranks the data and then performs Pearson's Calculation, which is the parametric version of this test (Field, 2013). Spearman's rho can determine the strength and direction of the monotonic relationship between the variables rather than the strength and direction of the lineal relationship, which is what is measured using Pearson's calculation. Monotonic means that as the value of one variable increased then the other value will either increase or decrease also (Laerd Statistics, 2019).
When using Spearman's Rank there are two assumptions outlined in Laerd Statistics (2019), these are:

(a) The data for the two variables are measured on an ordinal or continuous scale (eg. Likert Scale).
(b) There needs to be a monotonic relationship between the two variables.

Davies (2013) also discusses how Spearman's correlation is not very sensitive to outliers which do not fit within the 'trend' of the data so can be deemed as anomalous. The presence of these data points does not automatically invalidate the results from using Spearman's correlation (Laerd Statistics, 2019).

3.4.4.1.3 Mann-Whitney U Test

This test is the non-parametric equivalent of the unpaired T-test which only works when the data is parametric (Davis, 2013; Denscombe, 2010; Pallant, 2013). It is a tool which compares the medians of two independent groups on a continuous measure (Pallant, 2013). In this study, the continuous scale was the Likert Scale, and the Mann-Whitney test was used to determine if teachers who taught in different school levels, perceived science outreach programmes to be of more or lower importance for different groups of learners. While the non-parametric tests are less stringent; there are some general assumptions that have to be noted with the non-parametric techniques. The Mann-Whitney Test stipulates the following assumptions:

(a.) The dependent variable should be either continuous or ordinal (i.e. Likert).

(b.) The independent variable will consist of two independent groups that are categorical (i.e. whether they teach at a primary school or in a secondary school/college).

(c.) There must be different participants in each 'group'; this means that each person must only be counted once. For example, a teacher who identified working at a primary school cannot also state they work at a higher level.

3.4.4.1.4 Kruskal-Wallis H test

This is a non-parametric test that is used in a similar manner to the Mann-Whitney test, but it is appropriate when there are more than two conditions, it is also more simply called the Kruskal-Wallis test (Davie, 2013). It is an alternative to a one-way between-groups analysis of variance as it allows the researcher to compare continuous scores between more than two populations (Pallant, 2013). The assumptions of this test are the same as those outlined in the Mann-Whitney test; however, (b) there will be three or more groups instead of just two independent groups. In this study, the continuous scale was the Likert Scale, and the Kruskal-Wallis test was used to determine if the demographics of teachers have a significant impact on the perceived importance of science outreach programmes.
When comparing these different variables using the SPPS package this generates null hypotheses (H_0) and there is an indication as to whether to accept the H_0 or reject it. This H_0 is literal to what variable was inputted by the researcher to be tested so these results had to be interpreted by the researcher in terms of the research questions and actual hypotheses' being tested (see Figure 3-3).

Another difference of using this test compared to the Mann-Whitney test is that if the value is deemed significant, then post-hoc tests can determine between which group(s) the significance lies (Leard Statistics, 2018). This is essential in a Kruskal-Wallis test, as if SPSS rejected the H_0 then it is important to identify which groups present the significant difference. This post-hoc exercise will be further explained in section

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of How important do you think science outreach work at primary school level is the same across categories of School type.	Independent-Samples Kruskal-Wallis Test	.324	Retain the null hypothesis.
2	The distribution of How important do you consider chemistry outreach work to be at sixth form/college level? is the same across categories of School type.	Independent-Samples Kruskal-Wallis Test	.446	Retain the null hypothesis.
3	The distribution of How important do you consider science/chemistry work to be for girls? is the same across categories of School type.	Independent-Samples Kruskal-Wallis Test	.513	Retain the null hypothesis.
4	The distribution of How important do you consider science/chemistry outreach work to be for boys? is the same across categories of School type.	Independent-Samples Kruskal-Wallis Test	.476	Retain the null hypothesis.
5	The distribution of How important do you consider science/chemistry outreach work to be for pupil premium students? is the same across categories of School type.	Independent-Samples Kruskal-Wallis Test	.535	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 3-3 Example of the Kruskal-Wallis test when using the SPSS package (screenshot)

3.4.4.1.5 Friedman Test

The Friedman test is non-parametric and aimed to explore whether the same sample displays similar or different results when presented with three different conditions (Pallant, 2013). Its parametric equivalent is the paired T-test. This test is similar to the Wilcoxon test but was chosen as the same subjects were asked about three different conditions. However, this test was then used as post-hoc to determine where the significance lay. As with the Mann-Whitney and Kruskal-Wallis test, the Friedman test also adopts the same non-parametric assumptions, with the assumption the same group has been measured on three or more occasions (Laerd Statistics, 2018). The results from this statistical technique compare the mean rank for three sets of scores. In this study, this was used to determine if there was a perceived difference in the importance of science outreach programmes at different educational levels (Pallant, 2013).

3.4.4.1.6 Effect Size

When reporting statistical significance between different variables using *p*-value(s), these values depend upon the size of the effect and the size of the sample (Coe, 2002). This means that even if one of these values is quite small and the other large, then a significant result may still be present. Thus, when analysing non-parametric data, calculating the 'effect size' is important (Weunsch, 2015). Field (2013, p.79) describes this test as the means to "measure the magnitude of the observed effect". This value is also independent of the sample size and therefore, can be used to explore or further support substantive results. When measuring the effect size for non-parametric data, Cohen's *d* should be used (Leech and Onwuegbuzie, 2002; Lenhard and Lenhard, 2016). Therefore, the researcher accessed an 'Effect size calculator tool' designed by Lenhard and Lenhard (2016) to calculate an effect size for the non-parametric data. The researcher had to input the value from the Wilcoxon signed-rank test, Mann-Whitney-U or Kruskal-Wallis-H in order to calculate η^2 (eta squared). Field (2013) also identifies how this value can be calculated by finding the square root of R^2; the same as the correlation co-efficient (r) that is calculated using Spearman's Rank Correlation Coefficient (Section3.4.4.1.2).

The effect size can be interpreted in different ways depending on the literature referred to, some of these measures of effect size are highlighted in Table 3-7. By aligning different interpretations, it increases the validity of these results which are presented and discussed in Chapter 4.

Table 3-7 Table of interpretation of different effect size, adapted from Lenhard and Lenhard (2016)

r	r^2	η^2	**Interpretation of Cohen (1988)**	**Interpretation of Kinnear and Gray (2004)**	**Interpretation of Hattie (2009)**
< 0	-	-	Adverse Effect		
0.00	-	0.000	No Effect	-	Developmental effects
0.05	-	0.003			
0.10	< 0.01	0.010	Small Effect	Small Effect	Teacher effects
0.15	0.01	0.022		Medium Effect	
0.20	0.03	0.039			
0.24	0.05	0.060	Intermediate Effect		Zone of desired effects
0.29	0.07	0.083			
0.33	0.09	0.110			
0.37	> 0.10	0.140	Large Effect	Large Effect	
0.41	-	0.168			
0.45	-	0.200			

3.4.4.1.7 Post-hoc tests

Post-hoc analysis of the data allows the researcher to gain further insight into their results, although this in-depth exploration can increase the chance of a Type 1 error. A Type 1 error occurs when the researcher may reject the null hypothesis when it should have been accepted; these happen because further in-depth analysis may present values that are due to change and are not significant. Post-hoc comparisons, which are also known as posteriori, assists the researcher when deciding whether to reject the null hypothesis (Pallant, 2013). This process allows further exploration between groups, which gives the data increased depth, whilst ensuring there are more stringent criteria when presenting data as significant or not (Davis, 2013).

In both the Kruskal-Wallis Test and the Friedman Test, the Bonferroni adjustment was adopted to reduce the chance of a Type 1 error (Dunn, 1964), which Davis (2013, p.176) explains that the more these occur "significant results are, in fact, flukes". When choosing to use the Kruskal-Wallis test, these can be used to examine significance overall (Davis, 2013). Pallant (2013) recommends that to be able to control Type 1 errors, it is vital to keep the number of comparison groups to a minimum. The Bonferroni Correction was automatically applied via this Kruskal-Wallis H test in SPSS.

When using the Friedman test to calculate the value; divide the alpha level/*p*-value (significance level) by the number of tests used. In the case of the Friedman test, the significance level was 0.05, and three groups were compared. This means that the stricter alpha level/ significance level was 0.017. This new, stricter, alpha level was then used to determine significance when undertaking the Wilcoxon Signed Rank test as a post-hoc exercise. The Wilcoxon Signed Rank test is similar to the Friedman test but it a non-parametric test which determines the differences between the same groups when presented with two different times or conditions. Thus, it allowed the researcher to determine where the significant differences lay between different groups.

3.4.4.2 Qualitative analysis of the open-ended questions

The two open questions of the questionnaire invited teachers to respond freely. Cohen et al (2018) suggest that certain types of questions can make it difficult to make comparisons between respondents. However, there are tools to analyse qualitative data that allow talk and text to be reviewed strategically such as; content analysis, discourse analysis and narrative analysis (Denscombe, 2010). Thematic analysis (TA) is a widely used method for analysing qualitative data (Braun & Clarke, 2006; Clarke & Braun, 2017). Braun and Clarke's (2006) approach to thematic analysis is the most widely cited approach available; and was adopted within this study to identify, analyse and interpret patterns of meaning within the data set (Clarke & Braun, 2017). Thematic Analysis can be used in both conditions, which allows the researcher to be flexible in their approach, as discussed below.

3.4.4.2.1 Thematic Analysis

Braun and Clarke (2006) describe how TA does not align itself with a particular epistemology and as this researcher has adopted a pragmatic approach, it mirrors this general philosophy. Braun and Clarke (2017) outline the flexibility in the method makes it suitable for any sample size, constitution and methods adopted. As TA is not theoretically bound; it is different from other analytical methods that often seek patterns across data (Joffe & Yardley, 2004). Gibson and Brown (2009) outlined how the use of themes to analyse data is a common aspect of qualitative analysis and how 'thematic', allows the researcher to search for commonalities within the data. Therefore, it enables the user to identify, analyse and report patterns within the data concerning the research question; thus, themes, rather than a single piece of data is presented (Braun & Clarke, 2006).

Although the literature supporting this method is growing, there remains no absolute procedure in how to conduct thematic research (Attride-Stirling, 2001; Cohen et al, 2018; Tuckett, 2005). The process usually begins as soon as the researcher begins the collection process with the participant, as the researcher will actively look for or become aware of data which is notable or interesting (Braun and Clarke, 2006). Braun and Clarke (2006) suggest how to approach TA and outline phases as guidance for the analysis of this research. This is presented in Table 3-8 on the next page, along with a brief outline of its use in relation to this doctoral study.

Suri (2014) describes how thematic analysis may be 'theory-driven', and at this stage of the project there is a deductive approach; these themes will link to current topics within the literature review. Two questions in the questionnaire in Phase One, Study One were subjected to a thematic analysis; these were transcribed into a document from the paper questionnaires and reviewed. This process allowed the researcher to become more familiar with data that was analysed, in line with phase one of the TA process. Within these next two sections, the phase will refer to those of Braun and Clarke (2006) in Table 3-8 rather than the phases of this research.

Table 3-8 Adapted from Braun and Clarke (2006) Table 1 Phases of thematic analysis p.87 and placed in the context of this study.

Phase	Action	Description	In the context of this project
1	Familiarise yourself with your data.	Transcribing the data (if necessary), reading and re-reading data and noting down initial thoughts.	Following the collection of descriptive data, this was transcribed into a useable format and reviewed by the researcher.
2	Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set. Collating data relevant to each code.	Reading through each transcript, codes were generated and displayed using the NVivo 11 programme.
3	Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.	Codes were then reviewed and 'clustered' into themes.
4	Reviewing themes	Checking if the themes work in relation to the coded extracts (level 1) and the entire data set (level 2) generating a thematic 'map' of the analysis.	The raw data was then reviewed to check that codes had not been missed and that the context of the data that had been coded matched the theme.
5	Defining and naming themes	Ongoing analysis to refine the specifics of each theme and the overall 'story' the analysis tells, generating clear definitions and names for each theme.	Phase 4 meant some new codes had been generated which meant that codes were refined slightly. These were then presented and defined in chapter 4.
6	Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, the final analysis of selected extracts relating back to the research question and literature. This is presented in a scholarly report of the analysis.	Findings to be presented in Chapters 4, 6 and 7.

3.4.4.2.2 Coding and theme generation

Gibson and Brown (2009) outline that a 'code' is a process in which data is broken down into categories; thus, codes produce sets of data that have a commonality. There are two types of codes: apriori and empirical. These align themselves with a particular approach; deductively the apriori codes are defined prior to the review of the data; inductively empirical codes are generated as the data is studied (Becker et al., 1977). Therefore, in this study, both types of codes were generated. The researcher firstly coded anything that aligned with the pre-determined codes. The pre-determined codes were informed from existing literature as follows; 'engagement', 'utilising activities/resources, 'a wider knowledge of science careers available' and 'applications in a real-life context' (Cridge and Cridge, 2015), 'professional development of teachers'; and in addition, the delivery of these programmes, such as the 'involvement of external partners' (Gumaelius et al, 2016). Then following this initial process, the researcher was able to identify to determine empirical codes which emerged from the participants responses.

During the generation of these empirical codes, the researcher stepped away from the raw data, to attempt to code with a more 'inductive stance'. This involved the researcher identifying 'interesting' aspects and deriving new codes, by organising the data into meaningful groups (Tuckett, 2005). Braun and Clarke (2006) advised that when selecting data to be 'coded', the data should include further information, to ensure the context is not lost. Therefore, the codes generated allowed a meaning and context, which would support a valid argument when reporting the findings. All the coding was generated in the software package NVivo 11 Pro (QSR International Pty, 2017), as it is a software package that assists with organising this type of data.

Phase 3 asks the researcher to place these codes into themes; these are 'broader' umbrella terms in which the relevant codes are collated. Braun and Clarke (2006 p.10) describe how a theme "captures something important about the data in relation to the research question". They discuss what contributes to a theme in terms of quantity and quality and warn that they are not mutually exclusive. This is a stage of analysis which allows the researcher to link several codes together and refocus the analysis in terms of the research question. In this study, the themes were generated from a mixture of apriori and empirical codes. However, the themes encompassed both types of codes, which meant that they were essentially supported by the primary data and the literature. It was recommended by Braun and Clarke (2006) that a 'thematic map' could be produced to see the 'bigger picture'; and to assist with analysis in the next phases. This was achieved by generating a mind-map (see chapter 4.4.4 for an example of one of these) and allowed the researcher to review how different codes were grouped into a particular theme.

The next phase of the TA allowed the researcher to refine the proposed initial themes. Patton (1990) describes how these 'categories' or themes should be similar enough that they relate to one another, but that there is enough difference to warrant a new theme. These were achieved via a multi-step process by which the researcher printed hard copies of this data and codes and reviewed each data set for the code and checked that the data belonged to an appropriate code. The next step involved reviewing the data and checking that no codes had been missed. To ensure rigour during this process, the researcher asked three fellow Postgraduate Research (PGR) students (*n*=3) to code three different transcripts using the themes that had been identified. These colleagues acted as 'critical friends' as they have prior experience in similar qualitative research and understood the TA process. These 'critical friends' were asked to view the data, the codes generated, and themes created. Coghlan and Brydon-Miller (2014) describe how this idea of a 'critical friend' does not ensure objectivity of the data, but it does allow these additional people to look at a situation with their own lens and discuss whether their views align. Braun and Clarke (2006) themselves discuss how following the stages of TA is dependent on the researcher and by asking three critical friends to undertake this process, it allowed the researcher to justify codes and themes and make any adjustments if need be.

The next Phase Braun and Clarke (2006, p.22) ask of the researcher is to "refine and define" their themes. This was achieved by providing a description for each theme and presenting sub-themes, which were supported by extracts from the transcripts to justify the narrative of the theme. The indicators of success for this phase, according to Braun and Clarke (2006), are being able to summarise each theme in just a few sentences. This is presented in Chapter 4 as an analytical narrative of the responses and findings from Phase One, Study 1. An extract of the Thematic Analysis map for this study is shown in Table 3-9 on the next page to exemplify this process of the refinement of codes.

Table 3-9 Extract of Thematic Analysis Map from Study 1.

Links to literature	High order themes	Tertiary theme	Description	Raw data quotes from participants
Cridge and Cridge (2015)[a]	Outreach work inspires learners and promotes engagement and confidence in science.	Enthuse and engage	Any reference to students being engaged and enthused in science.	"It is most important to enthuse children about science." Participant 18P "Engages thinking about the 'big ideas'." Participant 19S
		Inspiration and motivation	Any reference to providing inspiration.	"Outreach in science provides the pupils with the context to become inspired by their current learning." Participant 10S "Inspiration and motivation." Participant 35P
		Confidence in science	Any references that suggest students feel more confident about science.	"Give pupils more confidence in their abilities on the subject." Participant 22S "Confidence to apply for level 3 courses." Participant 34S

3.5 STAGE 2: SEMI-STRUCTURED INTERVIEWS

3.5.1 OBJECTIVES

i. Collect detailed information regarding science outreach programmes which currently exist in a range of school settings.

ii. Gain a brief insight into teachers' views about science outreach activities running in participants schools and depict their thoughts regarding what works well and what does not work well, in terms of the design of the programme(s).

3.5.2 RATIONALE

Arksley and Knight (1999) argue that research is at its most powerful when the methods chosen are deliberate. For this stage of the study, participants were selected due to their ability to be descriptive in terms of the rich data produced, whilst allowing freedom to explore ideas and opinions. Interviews are a useful tool for collecting primary evidence that can be formally planned before data is collected (Suri, 2014). Therefore, the purpose of interviews in this study were to gather enriching data regarding outreach programmes that were in operation in particular schools within the NW of England.

Cohen et al (2018) point out that interviews align with questionnaires and in this research study, it is the information provided from responses to Q2 and Q8 of the questionnaire (see Appendix E: Example of completed questionnaire on paper and online) which will inform the initial questions for the interview. The interview was designed to ensure information collated would align with the research aims. A semi-structured approach was chosen due to being able to incorporates both benefits of using both open-response and closed-response questions (Cohen et al, 2018). Galletta (2013) discusses how semi-structured interviews ensure that responses align to the research via formulating purposeful questions, but also allows opportunity for the participants to openly share their experiences (the design of the interview itself is further discussed in Section 3.5.3). It was a further opportunity to delve deeper into the perceptions of teachers in relation to science outreach programmes. By combining both stages one and two in Phase One this allowed the earlier first stage to assist with participant recruitment in the interviews; Denscombe (2008) suggests that this can be a particular advantage of using mixed methods research.

Davies (2007) advised that the aim of an interview is to create an environment in which the participant can talk freely and offer a full range of responses. According to Gillham (2005), this is a critical difference between interviews and questionnaires; as most often interviewees are invited to offer their own response, not one that is often predetermined within the format of the questionnaire. Another key difference is that the response from an interviewee is interactive, allowing for a degree of adjustment or clarification. Whilst these advantages provide a clear rationale for conducting an interview, it is the skills of the interviewer who is conducting the interview that will generate accurate data (Kitwood, 1977; Davies, 2007; Gillham, 2005).

It is also worth considering that as this interview can be classified as 'standardized open-ended' as, wording, order and questions will all be determined in advance, this means that as the respondents' answer the same questions data is comparable thus, reducing bias (Patton, 1990). Whilst this is a positive aspect to this design, it does reduce the flexibility of the interview itself and the natural environment, which Davies (2007) suggests is beneficial as part of the interview process. As well as being aware of this, Cicourel (1964) highlights several unavoidable features of interviews such as differences in trust levels between both parties, avoidance tactics and misinterpretation of meaning. This was accounted for when utilising and interpreting the data as understanding the limitations of the interviews informed both the design and the analysis process.

3.5.3 Design

Davies (2007) describes how a good interview design will ensure possible eventualities present no problems; thus, in both sections of the interview all response types were anticipated, ensuring that the data collected could be used effectively. Therefore, within the design of the questions, there were prompts to ensure the information provided was complete and probes used to either provide clarity of a response or to explore themes in more detail (Davies, 2007). To also ensure all questions were viable a pre-pilot (*n*=1) and a pilot (*n*=1) study were conducted within the same school that was used in Stage 1 for the pilot questionnaire. It is known from accessing relevant information that this secondary school conducted science clubs and had links with primary schools. Therefore, their involvement in this pilot would improve the validity of the interview as it had not been pre-validated. This is described by Gillham (2005) who outlined the difference between pre-piloting and piloting; the 'pre-pilot' is a distinct stage whereby the questions can be 'tried out' and feedback is provided for each question, and the pilot interview can be deemed as a 'test' run, following which there should be very few changes. This aspect of the design contributes to the reliability of the data collected during this stage of the study.

The purpose of these interviews was to allow teachers to extend their ideas regarding their perceptions of outreach activities, which they have experienced first-hand. Therefore, the structure of the interviews needed to accommodate this data collection. The first section of the interview is structured, whereby each question will warrant a closed response as it allowed specific details regarding outreach programmes operating in school to be gathered. Gillham (2005) explains how these interviews are referred to as 'recording schedules'. Their main advantage is that they often counteract some of the disadvantages of surveys alone, such as incomplete responses to questions or quality of the response provided, as well as taking a relatively short time to complete. Arksey and Knight (1999) recall the advantage of using this structure as allowing descriptive information to be produced quickly. They also suggest that these questions are usually used before a more open-ended discussion. This literature informed design aspects for the interview used, as following the initial 'structured' questions, the remainder contained semi-structured interview questions. These questions encouraged teachers to provide an open response to their views of the type and nature of outreach activities occurring in their school. In addition, Askley and Knight (1999) and Gillham (2005), state that this form of interviewing is the most important as it balances the flexibility of response with ensuring purposeful data is obtained.

Three out of the four interview questions were semi-structured questions and these questions gathered further information about teachers' perceived benefits and drawbacks of outreach programmes. The three semi-structured questions also allowed the teacher to suggest a 'better way' of delivering science outreach activities. Each participant was asked the same three questions, which allowed the generated data to be directly compared and increase the reliability of the primary data. Therefore, descriptive data was able to be gathered in a timely manner that met the objectives of Phase One stage 2 the study. The inclusion of semi-structured questions allowed an exploration of key themes, allowing participants to add depth to their responses and provide ideas that may not been considered initially by the researcher (Galletta, 2013). A copy of the full interview schedule is presented in Appendix G: Interview Schedule.

3.5.4 Participants

Gillham (2005) discusses the time-cost factor for interviews to ensure this method of research is feasible; he calculated that for 15-one hour face to face interviews (taking into account travel), transcription and analysis, this would take a researcher a total of 345 hours. Therefore, to ensure these interviews were a feasible aspect of this PhD study, each interview (*n*=8) lasted about 20 minutes, thus reducing the cost-time factor. It was also important that the length of time of each interview was relatively short, as 'time' is often cited as a constraint for a teacher being involved in research (Cohen et al, 2018).

In terms of sample size, Gillham (2005) considers whether conducting large numbers of face-to-face interviews is necessary and if a 'pick and mix' method might be adapted whereby only 'key' interviews are conducted. The main aim of Phase One Study 2 was to collect richer data regarding outreach schemes that were highlighted in Study 1, thus participants 'opted-in' to being involved in Study 2 (the semi-structured interview). The responses from Study 1 were organised into school levels and then schools (if there were responses from teachers who attended the same school). After organising the questionnaire, participants were selected using purposive sampling methods. According to Gibson and Brown (2009), this is a process by which participants are selected based on their relevance to the research itself, which is drawn from a participant's role, experiences and thoughts. The criteria for selecting participants in this study were based on whether they indicated that science outreach work occurs at their school and the type of school itself (Bryman, 2012).

Based on the number of responses (*n*=52) from Stage 1 it was decided to select three participants from primary schools (*n=3*), three from secondary schools (*n=3*) and two from sixth form/college (*n=2*). There were only two participants from sixth form/colleges due to the limited data collected at this level in Stage 1. In addition to this, within the secondary school sample, two of these schools also had a sixth form provision and therefore accounted for the slightly smaller post-16 demographics within the sample of Stage 2. These eight participants represented 15.3% of the sample from Stage 1 and sought views from the range of educational levels in England and was also manageable within the time and cost constraints of this PhD study. If a teacher was approached who no longer wished to be involved with the research, then another participant was approached, this occurred until eight participants from the selected criteria were represented. This resulted in there being a slight skew towards female participants in Phase One, study 2 and Phase Two. A summary of the demographics of the participants at each stage of this PhD study are presented in Table 3-10.

Table 3-10 A summary of participant selection within the whole PhD Study

<table>
<tr><th>Phase/study</th><th>Sample selection</th><th colspan="12">Sample demographics</th></tr>
<tr><td rowspan="3">Phase One-Study 1 (Questionnaires)</td><td rowspan="3">Stratified random sampling from schools with the NW of England</td><td colspan="12">n=52
(overall demographics M=19, F=33)</td></tr>
<tr><td colspan="3">Primary school</td><td colspan="3">Secondary school</td><td colspan="2">Secondary school with sixth form</td><td colspan="2">All through school</td><td colspan="2">FE/Sixth form college</td></tr>
<tr><td colspan="3">M=3
F=13
n=16</td><td colspan="3">M=2
F=8
n=10</td><td colspan="2">M=12
F=11
n=23</td><td colspan="2">M=1
F=0
n=1</td><td colspan="2">M=1
F=1
n=2</td></tr>
<tr><td rowspan="3">Phase One-Study 2 (Interviews)</td><td rowspan="3">Purposeful sampling based on those who agreed to be further contacted from study 1.</td><td colspan="12">n=8
(overall demographics M=2, F=6)</td></tr>
<tr><td colspan="4">Primary school</td><td colspan="4">Secondary school</td><td colspan="4">FE/Sixth form college</td></tr>
<tr><td colspan="4">M=1
F=2
n=3</td><td colspan="4">M=0
F=3
n=3</td><td colspan="4">M=1
F=1
n=2</td></tr>
<tr><td rowspan="3">Phase Two (Focus groups (FG))</td><td rowspan="3">Opportunist sampling based on schools in the NW of England who participated in Science Outreach programmes.</td><td colspan="12">n=4
(overall demographics M=12, F=17)</td></tr>
<tr><td colspan="3">FG1
Secondary level</td><td colspan="3">FG2
Primary level</td><td colspan="3">FG3
Secondary level with sixth form</td><td colspan="3">FG4
Primary level</td></tr>
<tr><td colspan="3">M=3
F=4
n=7</td><td colspan="3">M=4
F=5
n=9</td><td colspan="3">M=4
F=4
n=8</td><td colspan="3">M=1
F=4
n=5</td></tr>
</table>

As these interviews were synchronous, it was agreed that the researcher met at the school in which the participant teaches, to ensure a familiar environment. In addition, each interview was conducted using university protocols that had been agreed through the ethics committee. For example, each participant was provided with an information sheet related to the purpose of the study and how the data would be anonymised. This is important so that participants were able to give informed consent to the ethically approved study (Gibson and Brown (2009). Finally, the participants were provided with a pseudo-ID to ensure anonymity; this was outlined in the participant sheet.

3.5.5 Data Analysis of semi-structured interviews

Analysing interviews involves several processes and decisions; these are explained in detail in the sections that follow and thereby provide a clearer sequence of how following the transcription of each interview, this was then used to present original findings. Gillham (2005) suggests that unless the researcher takes a superficial approach to analysing data, via either the use of categories or word/phrases counts, then the analysis will be an interpretive construct and itself be subjective. However, whilst the aim is to follow methods that will reduce the subjectivity of the data, there will always be some elements of interpretation and bias (Gibson and Brown, 2009).

It is mindful to acknowledge the prior experiences and behaviours self-construction of the individual interviewee; as a person's own view of themselves may not reflect their actions (Gillham, 2005). This means that although a participant may communicate an event in time in a certain way, this may not represent the true reality. Finally, it could be argued that by identifying oneself as an interviewer, the participant's behaviour changes towards the researcher as they can become more cautious or reserved. This identification of the researcher and their role is necessary to meet ethical expectations (Bryman, 2016).

3.5.5.1 Transcription

The transcription process is a translation of the verbal interviews occurred within this research study (Kress, 2005; Kvale, 2008). It is argued that even by transcribing the interview script, a researcher is interpreting the data, as it is a representation of a research process. Gibson and Brown (2009 p.110) highlight that "transcripts are data presented in a new, analytically focused way". Even though this process has limitations, it is the first stage that needs to occur to be able to inform analytic judgements regarding the data collected. If the researcher has a heightened awareness of their own interpretation, then they can proceed accordingly. It is important that this transcription process is methodically followed, as according to McLellan, MacQueen and Neidig (2003), vital data can be lost through poor transcription techniques.

During Study 2, the interviews were transcribed from an audio tape. Thus, context and meaning may have been lost due from the transcriptions, as capturing non-verbal communication, such as body language and how the interviewee answers a question, would be lost (Lapadat & Lindsay, 1999). In addition, time can also be a factor in the interpretation of the meaning behind participant communications. Therefore Misher (1991), describes how data is capable of endless reinterpretation. Following each interview, on the same day, the researcher composed a written account of the interview, to provide a narrative of the interview experience and the researcher's interpretation. Following the collection of the interviews, the audio recordings were then transcribed verbatim and were uploaded as sources to NVivo 11 pro software package (QSR International Pty, 2017). The interviews were then listened to alongside the transcript to ensure there had been no errors made during the transcription process, increasing the reliability of the transcribed data. Finally, by combining the narrative account of the interview alongside the transcript, this can assist with enhancing the meaning of what had been communicated, if analysing this data sometime later.

3.5.5.2 Continuing Thematic Analysis

Section 3.4.4.2.1 outlines the details of this method, and the same process was used to analyse the interview transcripts. The pre-determined deductive codes from Phase One stage 1, along with the emerging codes from this process, were used as a starting point for the analysis of the interviews. This is because both the questionnaire and interview were a deductive process, and the interview was a 'follow-up' to the questionnaire. Thus, the data from the interviews linked to the themes previously outlined. However, the semi-structured interview stage allowed participants to provide further detail regarding their engagement with outreach programmes. Hence, additional empirical codes were generated following the Phases 1-6 as previously identified by Braun and Clarke (2006) in Table 3-8.

3.6 PHASE TWO: GROUNDED THEORY ANALYSIS OF FOCUS GROUPS (BASED ON MODIFIED PRINCIPLES OF GT-CHARMAZ, 2014)

This phase of the research aimed to explore more deeply whether outreach work is sustainable and practical to support formal science education and to further develop the model which will implement these ideas. It also allows the further development of a more stream-lined model that focuses upon learners from a lower socio-economic background. To achieve this, Grounded Theory (GT) was selected as the approach as Bryman (2012) explains how grounded theory methodology (GTM) has become the most widely used framework for analysing qualitative data. This methodology advocated developing theories from data rather than deducing testable hypotheses from existing theories (Charmaz, 2014). This was important in this study as the intention was to generate a new model (or theory) based on the data and the constant comparative method as part of the GTM chosen allows the researcher to refine ideas as more data is collected. Harris (2015) confirms how GTM is different to other qualitative approaches as these often ask the researcher to collect data and then analyse it; however, with GT the idea is that data collection and analysis is a systematic and simultaneous process. In this instance, it meant that ideas could change the design of this model prior to the final presented version in Chapter 6.

Nagayama and Hasegawa (2014) discuss how major differences exist amongst GTM approaches. In this study, the constructivist approach to Grounded Theory (Charmaz, 2004, 2006) was adopted, as it is associated with a pragmatist approach, acknowledging the interactions of the researcher and the participants involved and how the theory is a construct of the researcher themselves (Birks and Mills, 2011). Charmaz (2014) outlines that during this initial coding process the researcher should remain open to exploring any possibility; however, due to the prior research activities and literature review this was not achievable in this case, as some of these ideas have already been defined and will inevitably have an impact and influence on this analysis. This does not mean however, that GT cannot be used, as Walls et al, (2010) suggest that if the researcher adopts an open mind and utilises the process of the constant comparison this may be still achievable. Thornberg (2012, p. 245) calls this process 'informed Grounded Theory', he explains how conducting a literature review before the coding is a way of ensuring that researchers recognise established theories and avoid 'reinventing the wheel'. It also reflects the fact that most researchers who are studying a particular field have some background knowledge of their subject and should not have to pretend to be a novice within the field.

3.6.1 Constructivist Grounded theory

Historically, change began as inductive qualitative inquiry in sociology began to shift from life histories and case studies to participant observation in the 1940s. However, at the time, there had been no firm theories or codes to match this 'shift'. Charmaz (2006) discusses how it was not until 1967 that Barney G. Glaser and Anselm L. Strauss wrote about how qualitative inquiry linked to methods of analysis in their publication of *The Discovery of Grounded Theory: Strategies for Qualitative Research*. The researchers had worked together on a project that looked at death and those dying in hospitals, and as they investigated ideas about dying at a variety of different hospitals, they began to produce systematic methodological approaches. As a result, other researchers were able to adopt a similar framework making it different from previous approaches.

When looking at GT as a methodology, it merges divergent disciplinary traditions. Charmaz (2014) explains how Columbia University positivist approaches were 'married' with Chicago school pragmatism and field research. Glaser had trained at Columbia University and wanted to develop codifying qualitative research; it was here that he formed many of the basic principles of GT. In contrast, Strauss's Chicago school background led him to take on a view of human beings as active agents within society, not passive. His views brought about notions of human agency, emergent processes, subjective meaning and problem-solving practices to GT as an open-ended study. Strauss's ideas supported theories linked to pragmatism informed symbolic interactionism; meaning that society, reality and self are constructed through interactions and thus rely on language and communication (Charmaz, 2014). Thus, society can be described as 'interpretive' whereby individuals act and then may change meanings after reflecting on their actions. It also takes on the view that people do actually think about consequences of their actions rather than simply responding to stimuli. This links to criticisms highlighted by Bulmer (1979) as it is questioned whether the researcher is able to only make their own theories in the later stages of this process. It would then be difficult to collect data in a 'neutral state' if the researcher were already embedding ideas as the data was still being collected.

Since their first publication in 1967 their GT has diverged, as in fact both researchers began to draw upon on dissimilar views. Charmaz (2014) describes how Strauss's (1987) book took a 'looser' approach than Glaser's 1978 publication and that

Glaser criticised later ideas of Strauss and Corbin (1990) as he suggests that that their newer ideas would force data analysed into preconceived categories and ignore emergence. Strauss never responded to Glaser's comments to contest any of these accusations and it has now "gained increasing acceptance from those qualitative researchers who adopt it in mixed-methods projects" (Charmaz, 2014, p.12). Charmaz (2014) suggests that this is where GT moved away from a positivism and claims that argues that "a constructivist approach is more favourable as society does not exist without the inclusion of human interaction." (Charmaz, 2000, p. 521). Thus, Charmaz (2014) builds upon the pragmatist underpinnings of GT and advancing interpretative analyses that acknowledge these constructions.

Adopting a constructivist GT approach gets rid of this notion of a neutral observer as the researcher begins with their own experiences and knowledge (Charmaz and Byrant, 2010, p.409). Charmaz (2014) further explains that this means that the researcher must examine rather than 'erase' how their privileges and preconceptions may shape the analysis and that their own values actually shape the facts in which they can identify with. Gillham (2005) also reflects this idea in his critique of conducting interviews as he explains how during the process, both the interviewer and interviewee are 'constructing' themselves in what they say, therefore inter-subjectivity is at the heart of all social interactions. It is suggested however, that this does not mean that the data is not useful but that it is imperative that this dimension is considered and acknowledged within this type of research. This is similar to the rationale behind the constructivist GT as Charmaz (2014)) explains how they chose to label this newer theory as 'constructivist' as to acknowledge a researcher's own background and how this could impact upon the construction and interpretation of the data. Upon Charmaz's (2014) initial presentation of this updated theory in 1993 it caused disarray as other, experts in GT suggested that her version strayed from earlier approaches. However, constructivist GT sits well with other constructivist ideas of Vygotsky (1962) and Lincoln (2010) who outline ideas about social contexts, interaction, sharing viewpoints and interpretive understandings how these are intertwined on a social plane.

3.6.1.1 Using Principles of Modified Grounded theory

When considering GT as a methodology for this phase of the research project, the above section provides a clear outline how this is a tool in which the researcher can approach data in an open mind-set and allow the journey of the data to drive the changes and 'ground' the theory. In the context of this research, this methodology allows the researcher to confidently summarise findings surrounding a teacher's stance on engaging with science outreach programmes and a process in which these voices could provide feedback to inform the analysis of phase one.

Whatever 'branch' of GT is chosen, there are some key ideas about allowing concepts to emerge to have the openness to explore these (Glaser, 1992). However, it was felt that the researcher was not starting from a completely 'open' stance due to the previous phase and that due to time restrictions and problems with recruitment then having the means to explore these themes would be compromised. Whiteley (2004, p. 32) discusses similar issues with ensuring the 'purity' of the GT and discussed how their approach to the GTM was taken "not uncritically but pragmatically". Similarly, this researcher used this GT approach, but made pragmatic decisions to ensure that the outcomes were achieved (see chapter 1) and this unfortunately meant that the amount of theoretical sampling was limited due to the logistics of this doctoral study. Thus, identifying the methodology as 'modified' allows the researcher to adopt the practices of GT but ensure that it does not claim to follow a methodology to its entirety.

Blowers' (2018) study about professional integrity in pre-registration nurse education for example, was informed by Charmaz's (2002, 2006) approach to constructivist GT who used discrete episodes of data collection in a shorter timeframe. Nagayama and Hasegawa (2014) also outlined how their study was based on this modified GT approach as it aimed to adopt the theoretical and content properties of GT but added their own modifications. Again, it was "judged to be appropriate for this study because its aim was to develop a theory within a limited scope" (Nagayama and Hasegawa, 2014, p. 285), and provided a further rationale for the use of this adapted methodology. Thornberg (2012) adopted an 'informed' approach to GT as they added literature review strategies to the GT approach. In this study the literature review was conducted at the beginning of phase one, as outlined in Chapter 2 and these are what assisted with the generation of the research questions themselves.

Pierce (1958) was an American Pragmatist who discussed the idea of an 'abductive' approach to research, whereby it was explained that this process lies between the inductive and deductive devices that are more commonly used (Thornberg, 2012). Schurz (2008) provided an analogy of the abductive approach which described it as:

> Different from the situation of induction, in abduction problems we are confronted with thousands of possible explanatory conjectures (or conclusions)

> – everyone in the village might be the murderer. The essential function of abduction is their role as search strategies which tell us which explanatory conjecture, we should set out first to further inquiry ... or more generally, which suggest us a short and most promising (though not necessarily successful) path through the exponentially explosive search space of possible explanatory reasons

(Schurz, 2008, p. 203–204).

Thus, using principles of constructivist Grounded Theory (GT) (Charmaz, 2014) supports the pragmatist views of the researcher. Whereby, this study attempted to follow the steps of Charmaz's (2014) constructivist GT but due to time constraints, Phase Two (see Chapter 5) only adopted principles of the methodology. For example, memo writing was an integral part of this process which is crucial during the refinement of codes into categories (Birks and Mills, 2011). Considering these constraints therefore, a different approach such as Thematic Analysis (Braun and Clarke, 2006) which was utilised in Phase One, was contemplated. However, the aim of this phase was to develop a theory as Birks and Mills (2011, p.134) described how "the inherent beauty of a grounded theory lies in how each component integrates together." Thus, it is through understanding these relationships between themes that theories are generated (Urquhart, 2013). Therefore, even in its limited nature, following principles of constructivist GT (Charmaz, 2014) extends understanding about teacher's perceptions of their engagement with science to build a small-scale theory (see Table 5-4 in Chapter 5.).

3.6.2 Research Process using M-GT

The design of this phase is summarised by the stages outlined in Figure 3-4. It follows Charmaz's (2014) approach to Constructivist GT.

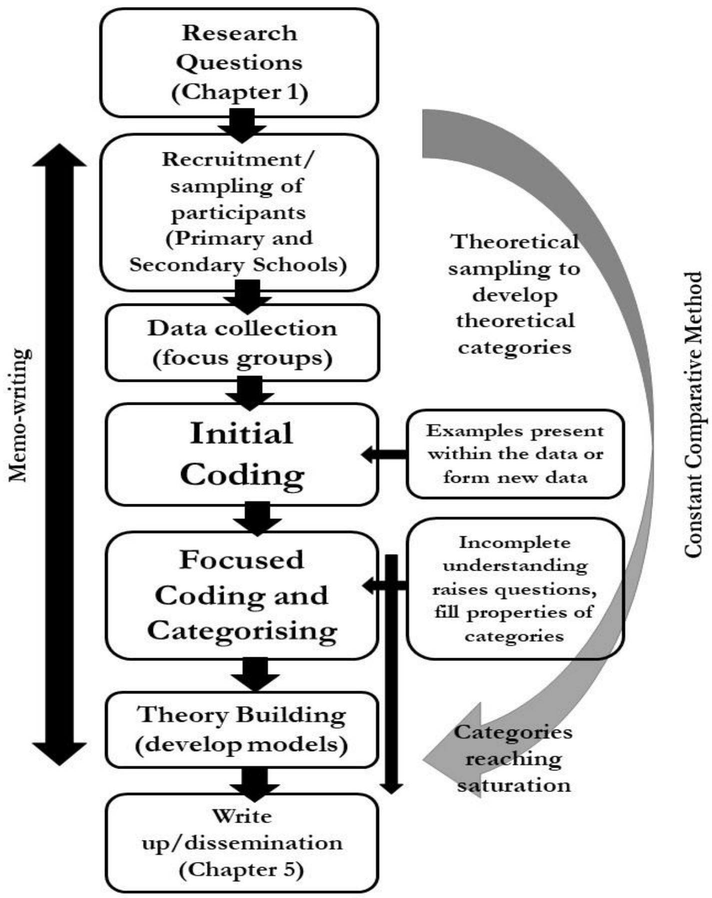


Figure 3-4 A visual representation of grounded theory which originally featured in Tweed and Charmaz (2011, p.133)

3.6.2.1 Research Questions

Section 1.5 details the formation of the research questions. In the context of this phase of the study the focus remains on RQ2 and RQ3. There are indicated below in the context of this phase.

- What do teachers in the North-West of England think about science-based outreach programmes, especially in the context of children's social demography?
- How can science outreach become a more effective intervention tool within the classroom?

3.6.2.2 Data collection

In this phase, the data collection process was generated via focus groups. Birks and Mills (2011) outline this mode of data collection is an extension of the standard interview and therefore suggest that these are the general principles followed.

Check and Schutt (2012) describe how focus groups allow the leader to conduct unstructured group interviews which centre on a particular topic of interest. The researcher (group moderator) will have an interview schedule (see Appendix K: Focus Group Schedule) but the dynamics and direction of the discussion may change; and the researcher will respond to these responses (Brown, 1999). It is recommended that focus groups contain about 7-10 people and that these are repeated to a point of saturation (Check and Schutt, 2012). In the case of the participants, as they are co-workers the group are described as homogeneous; this may mean that they are more open and comfortable to share opinions, but it means maybe not as many new ideas are generated than would be seen in a heterogeneous group (Brown, 1999). Although this can form a lot of debate into which groups to select, Krueger and Casey (2000) generalise that a good focus group will obtain honest answers, on important topics from people who know these areas.

Focus groups are an effective method to discover new findings and explore hidden meanings. Check (2002) conducted a focus group to investigate what may be causing the high turnover of school principals. In this setting it was noted that participants were able to build upon each other's comments in a way that would not be possible with an individual interview. In terms of using focus groups in GT, Birks and Mills (2011) warn that these can be trickier when attempting to follow theoretical leads. Therefore, by sharing the diagram of the model which was updated during the analysis process it kept the focus groups moving forwards in a theoretical context.

The purpose of the focus groups were twofold. Firstly, they provided further insight into teacher's perceptions of science outreach programmes and how they may impact upon a particular group of learners. Secondly, it is a feedback group which can comment on the model/analysis from Phase One. Bloor et al (2001) describe how these comments can be used to extend and deepen the thought of this prior analysis, though not validate it. Using a focus group, rather than individual interviews, help to remove researcher bias as the researcher is there to facilitate discussion. Charmaz (2014) discusses that intensive interviewing is often the method which grounded theorists rely on. However, focus groups provide an opportunity for "a socially legitimised occasion for participants to engage in 'retrospective introspection', to attempt collectively to tease out preciously taken for granted assumptions" (Bloor et al, 2011 p.6). This can only really be teased out from a group setting or an ethnographic study; however, in an increasingly private and data focused society these are becoming more difficult to organise. For example, an ethnographic study could have been used within this phase, but no schools could be recruited for this so focus groups were a more viable research approach that could offer a similar level of insight.

3.6.2.3 Recruitment and sampling participants

The schools for involved in the focus groups were recruited via opportunist sampling, it was also preferable that none of the participants has being involved in study 2. This is because the rationale behind this phase was to gain feedback and critique the model that had been designed based on Phase One data. The group of participants were pre-existing, and this is advantageous for both practical and data focused reasons. Farquhar and Das (1999) states how this further protect participant anonymity as you just need data from the 'group' and do not need to record personal details. Additionally, Kitzinger (1994) suggests that using a group of people who already know each other could mean that may feel confident to challenge or question their fellow participant as these groups further mimic the normal social context in which ideas are formed. Though it is important to be aware and manage over-discourse in which a participant may reveal information that they wish they hadn't and may regret doing so (Morgan and Kruger, 1993).

The opposing argument to this is that in a group of strangers you may feel more comfortable to speak more freely (Bloor et al, 2001). However, in this activity the importance was placed on gathering more views and gaining feedback on the preliminary model and pre-existing groups were a much more viable recruitment option. Thompson (1999) suggests that six to eight is the optimum number for those participating in the focus group and this was the desired aim for all groups, though it was acknowledged that it was just an 'optimum' and the opportunity to collect data would take precedence over numbers.

In total, four focus groups were conducted (n=4) which sought teacher's perceptions of science outreach programmes for individuals across the 5-19 age range. Urquhart (2013) describes how unlike some other qualitative research methods; GT allows data to present a chain of events. In this case, after the first two focus groups were conducted in a primary and secondary school (n=2), data was analysed and identified as the 'first wave' of data collection which supports the iterative approach (Harris, 2015). For both these focus group transcripts, open coding was used to generate categories which enabled the modification and generation of the models. This meant that during the second wave the transcripts (*n*=2) were initially reviewed using focused coding, and theoretical sampling allowed categories to be refined (Charmaz, 2014).

3.6.2.4 Initial Coding and memos

Charmaz (2014) described how coding is an essential step in being able to link the data that has been collected to being able to develop theories that explain this data. Glaser (1978, 2002) requires these to be open ended and without preconceived ideas, but constructivist GT acknowledges the researcher's prior experiences, skills and ideas. The coding process allowed the researcher to then define what was happening and as a result present some rationale as to why. To assist with this, the researcher may choose to use computer software packages to assist them with the analysis process, such as NVivo (Birks and Mills, 2011). However, it was decided that the analysis process would be completed by hand and codes would be collated using basic tools within Microsoft Office Word (Appendix O: SPSS worked examples regarding the importance of science outreach at different educations levels). Whilst the rigour of the computer software packages may be commendable (Zamawe, 2015), Glaser (1978) prefers the more traditional hands-on approach nature as it was described how it allows the researcher to work more freely. Hence, this manual approach is still favoured by many researchers in the abstraction of codes whether using computer aided software or not (Soliman and Kan, 2004).

In addition to the coding process in GT, you go beyond these labels that are added to the data and try to make sense and observations as you go through this process via producing memos whilst coding. This step of memoing is what assists with the ability to weave in and out of the analysis process and fully engage with your research, Birks and Mills (2011, p.40) describe how memoing is the "cornerstone of quality". Charmaz and Byrant (2010) also discuss how the memo process demonstrates how the researcher links emerging theoretical analysis and the data and therefore, provides evidence for the generation of categories. Thus, memos were collected throughout the whole process to share inhibited ideas about the codes and the process, this memoing was done by hand on the copy of the transcripts in a different colour (see Appendix L: Examples of focus group transcript with examples of Initial codes and memos). This was carried out simultaneously during the open/initial coding process as it is advised that coding should be interrupted to write a memo, so these ideas are not lost (Urquhart, 2013). However, whilst Urquhart (2013) advises that the data and memos should be kept separate to assist with the process of abstraction, time was a limited factor and due to the practicality, it meant these were kept together on this occasion. Nevertheless, the memos generated were purposeful as they were used to shape and inform each wave of the GT process by ensuring that there is purposeful time to focus on the codes and compare and define links between then (Charmaz, 2014).

The first stage outlined in this process is to conduct line-by-line coding. This was depicted by Glaser (1978) in their early process of GT; although, this was later critiqued by the same researcher in 1992 who thought that this 'line-by-line' process generated too many categories and somewhat over complicated the process (Glaser, 1992). Charmaz (2014) does find that this process is useful as ideas will not be missed due to the fine scrutiny of the data. However, coding incident-by-incident follows the same principles of the line-by-line process and Charmaz (2014) suggests that this is an effective way to code as the researcher becomes more familiar with previously coded incidents. Therefore, following the first wave of focus groups, the researcher adopted an incident-by-incident coding technique.

These initial codes are raw in nature; to move forward with the analysis the researcher is required to make decisions about these codes and group them so that they make the most analytical sense. Charmaz (2014, p. 138) describes how in doing so, "focused coding expedites your analytical work enormously without sacrificing the detail contained in your data and initial codes." These focused codes are more conceptual, and it required the researcher to look at what the initial codes revealed and how the memos may link these; this was how the focused codes were generated and defined. As this GT method follows the constructivist approach it is recognised that these definitions may be drawn from the researchers own unique view and experiences (Charmaz, 2014). Birks and Mills (2011) compare this intermediate coding phase with Glaser's (1978) selective coding.

In Charmaz's (2014) Constructivist GT also has an additional intermediate coding process which is known as 'axial' coding. It is defined by Strauss and Corbin (1990, p.96) as "a set of procedures whereby data are put back together in new ways after open coding, by making connections between (and within) categories". Charmaz (2014) however suggests that this stage can extend or limit visions, depending on the researcher. Therefore, it is suggested that researchers who "prefer simple, flexible guidelines-and cam tolerate ambiguity-do not need to do axial coding" (Charmaz, 2014, p. 148). In this piece of research this stage of coding was not required as leads were followed that emerged from the empirical data.

Several focused codes became preliminary categories and memos were used to build and clarify what these consisted of to become more substantive codes (Urquhart, 2013). Theoretical coding requires the researcher to consider the relationships between the categories theorised thus far (Urquhart, 2013). Charmaz (2014, p.150) agrees as it is described how theoretical coding may help to conceptualise how the substantive categories are linked and move the "analytic story in a theoretical direction". This process is viewed as the act of building theory (Urquhart, 2013) and is part of the advanced coding process Birks and Mills (2011). Harris (2015) explains how these categories may be developed and refined when revisiting data. In this study, taking a little a break between the focused coding process and categorisation it assisted with this process (Charmaz, 2014).

3.6.2.5 Theoretical Sampling

One of the key differences between GT and other qualitative approaches is that rather than analysing the data after the collection process, it requires the researcher to gather data and analyse this as the same time (Harris, 2015). Whilst the approach to the initial data and coding process is meant to be inductive, the simultaneous analysis means that deduction will occur, and this requires the researcher to use these findings to shape the subsequent data collected. Harris (2015) summarises that this turn is known as 'theoretical sampling' and Urquhart (2013) explains how this process is a key strategy for building GT.

Whilst the tentative categories generated may provide some intrigue, to be able to view these substantively more data needs to be collected. Charmaz (2014) also calls this strategy theoretical sampling as it allows categories to be elaborated and refined. This type of sampling is different to others as it does not dictate how to start the data collection process but gives a guide of where you should go. This theoretical sampling was conducted via focus group 3 and focus group 4 and the participants were able to provide feedback on the updated model presented. This relates back to Charmaz's (2014) purpose of theoretical sampling as a tool to gain further data to make categories explicit, not increasing statistical generality. This was the case in this study as the theoretical sampling sought to add further depths to the categories generated and justify the analytical changes made to the model.

The m-GT aspect centred upon the fact that this theoretical sampling was limited in number. Urquhart (2013) outlines that data collection may stop when no new conceptualisations emerge and Charmaz (2014, p.213) highlighted that this will be at the point where "the properties of the theoretical categories are 'saturated' with data". It is discussed that in a small-scale study this can be proclaimed too early and is treated with a level of scepticism. After the fourth group there were only a few new codes generated and very minimal changes suggested. Therefore, the researcher still felt confident that theories generated were 'grounded' in data, though they may not have reached 'saturation' in the Grounded Theorist sense (Charmaz, 2014). The researcher addresses and explains this in their discussion of the theories generated (see Chapter 5).

3.6.2.6 Theory generation

Following the process of organising focused codes into categories, substantive codes were generated by considering these relationships. Urquhart (2013, p.89) acknowledges this refinement process as "the first thing is to realise that coding is, of necessity, an iterative and reflective process" and that "part of theorising involves looking at codes and debating their meanings and relationships." These two pieces of advice guided the processes whereby the substantive codes have been refined to those presented in Chapter 5 (see Figure 5-4). The researcher also decided to draw upon Spradley's (1979) semantic relationships as the iterative processes meant that familiarisation with these helped to organise these categories into codes. To assist further with this theoretical development, it required the researcher to integrate memos and categories to create and refine theoretical links (Charmaz, 2014). When revising the memos associated with the categories these were used to assist with the sorting process. To aid with this process, the researcher constructed diagrams (see Appendix R: GT Diagramming to assist with codes and theory building (rough workings)) to make logical sense of the empirical data, this was done by hand. Clarke (2005) discusses how the researcher can plot the relative strength and weakness of these concepts and show how the grounded theory fits together. It is also a tool which "sharpens the relationships among your theoretical categories" Charmaz (2014, p. 224). This process generated its own memos which have been included in the discussion of the data in Chapter 5.

Birks and Mills (2011, p. 112-113) define theory as "an exploratory scheme compromising of a set of concepts related to each other through logical patterns or connectivity". These definitions may change based on an individual's philosophical stance; positivists may seek theory for explanation whereas interpretivists may seek increased understanding. This can cause disagreement throughout the Grounded Theorist community; however, as a pragmatist the researcher sees the development of the theory in this study as one that encompasses both and favours the definition of Thonberg and Charmaz (2012, p. 41): "A theory states relationships between abstract concepts and may aim for either explanation or understanding". When placing theory in the context of constructivist GT there are several key features that differ from objectivist GT. These are adapted for the relevance to this study and summarised in the Table 3-11:

Table 3-11 Objectivist and Constructivist Grounded Theory: Comparisons and Contrasts (Adapted and Amended from Charmaz (2014). Constructing Grounded Theory (2nd Ed), London: SAGE Publications Ltd p. 236

	OBJECTIVIST GROUNDED THEORY	CONSTRUCTIVIST GROUNDED THEORY
Foundational Assumptions	• Assumes discovery of data. • Assumes conceptualisations emerge from data analysis.	• Assumes mutual construction of data through interaction. • Assumes researcher constructs categories.
Objectives	• Aims to create a theory that fits, works, has relevance and is modifiable (Glaser, 1978).	• Aims to create theory that has credibility, originality, resonance and usefulness.
Implications for data analysis	• Views data analysis as an objective process. • Sees emergent categories as forming the analysis.	• Acknowledges subjectivities throughout data analysis. • Views co-constructed data as beginning the analytical direction.

It emphasises how data and the analysis of this is created from experiences and relationships and how their relationship with these and their participants shapes the theory which emerges. Even though a 'modified' approach has been taken to this phase due to time constraints and small data set, the researcher identifies that the results discussed in chapter 5 have been co-constructed with the participants. It is also recognised that the researcher's own experiences will have had an unconscious bias on the construction of the categories which led to the theory development.

When constructing the theories for Phase Two, it is important to acknowledge how the focus groups contained three sections and they were analysed separately (see Table 3-12). The theories generated in section one aimed to provide further understanding of the phenomenon and the theories for section two and three aimed to provide a sort of explanation for the optimum design and delivery of science outreach in the form of a model. The theories are presented and discussed in Chapter 5. Urquhart (2013) discusses that a criticism of the GTM is that it only produces low-level theories and recognised that there is some truth in these notions. Therefore, the practice of 'scaling up' a theory allows the emergent theory generated through GT to be placed in the context of other literature and can link to 'higher level' or more formal theories. The results from this process are presented in Chapter 6

Table 3-12 Summary of the analysis and intended outcomes of each section with the focus groups

Part	Aim	Outcome
1	To explore teacher's views of science outreach programmes.	A theory which outlines teachers' beliefs about science outreach programmes.
2	Identify what the pros and cons are about the 'optimum science outreach mode' and make any suggestions for changes.	An updated and 'final optimum model for science outreach'
3	Consider which aspects of this model may be the most impactful for learners from a lower socio-economic background.	A model which outlines which features of the 'final optimum model for science outreach' are most important as a focal point for this specific group of learners.

When writing up these theories, unlike other qualitative research, it is the categories and their relationships and how these theories were constructed which take a pivotal role (Birks and Mills, 2011). The write up of these findings is also considered still to be part of the GT process as Charmaz (2014) explains how this writing process presents opportunities for the drafting of new ideas. The generation of this 'storyline' (Birks and Mills, 2011) is observed in Chapter 5and Chapter 6 where the processes of coding, theorising and upscaling take place. As part of the m-GT approach this again is on a much smaller scale than one would expect, but the researcher stayed true to following the steps and practices of the Constructivist GT approach presented by Charmaz (2014).

3.7 PRESENTING THE FINDINGS

Presenting findings appropriately and effectively is important following the analysis of the data (Cohen et al, 2018). The researcher chooses the most effective and meaningful presentational modes such as tables, graphics and clustering information (Marshall and Rossman, 2016). Initially, it was decided that each data collection instrument (questionnaire, interview and focus groups respectability) would be presented discretely, as Cohen et al (2018, p.662) explain that "this approach retains fidelity to the coherence and integrity of the data". However, a critique of this approach is due to its discrete process connections between each data collection-point, could be lost. Therefore, to ensure data did remain connected (especially as TA was used across both Study One and Study Two), data was organised and presented in response to the research questions in Chapter 7. Cohen et al (2018) explains how this approach aims to return the reader back to the initial research problems that drive the inquiry. Thus, these findings are depicted in the generation of the 'optimum science outreach model for sustained impact' in Chapter 6, and 'reviewed consistently through the remaining chapters. Birks and Mills (2011) discuss how illustrative examples can add meaning and are memorable for the audience, and models are therefore an effective representation of the data. The illustrative model provided a cohesive presentation tool throughout both Phases of this research study. It was clear how each data collection-point informed the developmental phases of the proposed outreach model.

3.8 ETHICAL APPROVAL

To be able to collect data from participants, ethical approval was granted from the ethics committee in the Faculty of Education, Health and Community at Liverpool John Moores University (LJMU). Bryman (2016) explains that having a clear understanding of risks and ethical procedures are imperative for all research. Therefore, risks within this research study, have been addressed in line with LJMU policies and processes. While it was considered by the researcher that the risks to the researcher and the participants were relatively low in terms of the data collection methods (questionnaires, interviews and focus groups); in order to further reduce the risk to the participants, individuals were provided with participant information sheets, explaining the research study. This allowed the participants to make an informed decision as to whether they participated in the study and their right to withdraw at any time (Cohen et al, 2018) (see Appendix D: Ethics approval and participant/gatekeeper information sheets). This aspect of the research process was also important as according to Taylor, Bogdan & De Vault (2015), consent is key in ensuring that the research is conducted ethically.

3.8.1 GAINING ETHICAL APPROVAL

For this doctoral study, to gain ethical approval there were processes in place to ensure the low risks identified had been considered. The participant information sheet provided a platform for this, as it contained detailed information regarding the study, the location and time of where the research activity would take place and how any activity may present a risk. The greatest risk within the study, was perceived to be during the individual interviews and focus groups; therefore, a risk assessment of this exercise was undertaken and included within the ethics application. The risk assessment focused upon ensuring the participant felt comfortable and safe answering the questions, whilst considering the safety of the researcher, who travelled to meet participants at their workplace.

Ethical approval was granted on the basis that the study remained anonymous. This was indicated on the participant sheets and storage of consent forms/raw data was on a password protected university account. Hard copies of data collected, including audio files, were stored in a lockable filing cabinet (to which only the researcher had access), which was in a lockable office space. This raw data was only shared with supervisors, who had agreed to protect the anonymity of the participants. Within the results presented, school name and staff names will not appear within the text. Finally, signed consent was sought from participants for questionnaires, interviews and focus groups. During Phase Two, consent was also obtained from the head-teachers of the schools involved, as they were identified as gatekeepers within this process. This was conducted under approval of the LJMU ethics committee.

3.8.2 Researcher positionality

Cohen et al (2018) recognise how a researcher still remains a part of the social world that they are researching and as they have a crucial role in the creation of knowledge, they need to understand their 'positionality' within this. This process is known as reflexivity, whereby the researcher is able to continuously acknowledge their past experiences and values and how these shape the research activity (Barrett, Kajamaa and Johnston, 2020). Whilst in some cases this can be beneficial to develop rapport or facilitate research design, it remains a key issue in terms of researcher bias (Cohen et al, 2018). To be a highly reflexive researcher, it is suggested that the researcher needs to be able to self-appraise their role throughout each stage of the research process and that they are aware and monitor any interactions that might affect the research. Thus, this reflexive process beings with an account of the researcher's background and experiences in the context of this research study:

> My first experience of action research was when compiling my undergraduate dissertation during my Science teaching degree. I began to realise how rewarding this experience was when I was able to conclude what factors may have changed pupils' perceptions regarding science

during the transition in England from primary (aged 5-11 year old) to secondary school (aged 11-16/18 year old). Although this was a small-scale study, it was a pivotal point in my own development, and I realised how interested I was in ensuring science is accessible for all. This inspired me to enrol on an MSc entitled 'Science and Society' and my first critical research project allowed me to explore how socio-economic status affects understanding and attainment in science. This research complemented my teaching practice as it allowed me to implement some of my findings within lessons such as, 'science in the news' and how I contextualised learning through enhancement in 'out of classroom settings'. During my MSc, I also explored how groups such as the Royal Society (RS), The Institute of Physics (IoP) and the RSC work to enhance science learning within schools, communities and the general public. The awareness of the programmes promoted by these bodies gives me an understanding of the science outreach initiatives in the UK and Ireland.

In my MSc, I studied how science is communicated to the public outside of a classroom context. I was particularly interested how science communication has progressed from the transmission model, which was didactic, to one that is more active and involves engagement (Smidt et al, 2009). It was interesting to discover how technology was used to enhance this level of communication between science and society. I developed a strong belief , that it is important as a teaching practitioner to ensure that learners link their understanding in school to the world around them, as research suggest, especially for girls, it is it the context learning in science that increases the enjoyment of the subject (Mujtaba and Reiss, 2013). Thus, I began to realise the relationship between schools and alternative learning platforms is one that needed developing, and I have relished the opportunity to explore some of these themes as part of this doctoral study.

Additionally, I am also a former science teacher and the school I taught in had an above average population of pupils from a lower socio-economic background. I was able to attend trips and talks with museums and universities as part of various outreach programmes and have experience of these with children in upper primary school and throughout secondary and FE education. I also grew up in a 'working class' area and whilst at school myself, I was told that being from my town meant I might get into some 'top universities' because of my demographic. This meant that I had a range of teaching science across all educational levels and knew what it was like to be from an under-represented group.

Therefore, as the researcher describes themselves as someone from a working-class background and a teacher who has worked with the demographics that are focused upon within the research, the researcher's positionality can be described as that of an 'insider' (Blackie, 2007). Kerstetter (2012) explains how qualitative researchers often debate about the benefits and drawbacks of the researcher belonging to the same community in which they are investigating. Being an 'outsider' suggests that the process and analysis of the research is more 'neutral' and detached, which may reduce researcher bias. On the other hand, the 'insider' can find themselves more uniquely positioned to be able to have a deeper understanding of the participants which they are also members of. Kerstetter (2012, p.100) states "that outsider researchers will never truly understand a culture or situation if they have not experienced it" and similarly, Gillies and Alldred (2002) ponder how a researcher can or should represent a group to which they do not belong. When considering their position as an 'insider' throughout the research process, the researcher reflected how:

> It was my own background that sparked interest in this area of research and assisted me with the initial design and formulation of the research questions. I believe I have a unique insight into the data that will be collected from this PhD study. These experiences will be used to enrich the design of the study and the interpretation of the data generated. For example, being a teacher has enabled me to have a deeper understanding of the pragmatic issues of managing a classroom and delivering the science curriculum to learners. I have found being an 'insider' useful during several stages of the research design, for example; in designing an original questionnaire, creating the interview schedule to ensure the questions are framed correctly for teachers and when interviewing teachers to make them feel comfortable. It was also particularly useful when conducting focus groups as the nature of this research tool means that it is the participants who lead the discussion. As a facilitator in the focus group process being an 'insider' meant that when the discussion might have seemingly 'wandered off topic' I was more aware of why it could be important and relevant. For example, when participants were talking about exam pressures this could have been mistaken as participants moving away from the focus point.

Whilst the researcher viewed themselves as an 'insider', Khatri and Ozano (2018) describes how understanding one's positionality also links to how others may view the researcher too. The researcher did align themselves with the participants, but as they were affiliated with a HEI as a researcher, the participants might not have agreed. Therefore, the researcher's positionality should not be labelled as a complete 'insider'. Kerstetter (2012) discuss the space in between the insider/outsider doctrine and how identities are often relative and that they may change throughout the research process. For example, at the start of this study the researcher had recently left the classroom and therefore could be deemed as more of an 'insider' compared to nearly three years later during the latter data collection and analysis process.

Whilst it is interesting to understand how pure the researcher's 'insider' label is, it is recognising this position in general that is more important. This is because the researcher can focus on acknowledging how they tried to separate these experiences and reflect upon personal bias to ensure reliability in their findings. Cohen et al (2018, p.270) describe how reliability of findings may also be referred to as 'credibility' or 'trustworthiness'. In qualitative research (which the MMR design of this study is skewed towards), reliability is deemed as the balance between what has been recorded as data and what may actually occur in the natural setting. To achieve this Cohen et al (2018) identify several steps that the research may take to ensure reliable results and reduce researcher bias. Within this research design some strategies adopted were; making sure the questionnaires and interviews were purposefully structured and the interviews contained planned prompts and probes; allowing for the participants to take their time to respond; keeping to the point and matters at hand. There were also several other measures taken to ensure results were trustworthy, these are discussed in the context of the research tool adopted and how results were analysed and are identified and explained throughout this thesis.

3.9 CHAPTER SUMMARY

The purpose of this chapter was to outline how and why data would be safely collected as part of this PhD research study. Date collection methods in Phase One include a mixed quantitative and qualitative questionnaire for stage 1 and semi-structured interviews for stage 2. The quantitative data was analysed via standard statistical tests, whilst the qualitative data was analysed using Thematic Analysis (TA), using Braun and Clarke's (2006 framework). For Phase Two of the study, a Grounded Theory methodology (GTM) was used to be able to process and analyse data from focus groups. The methodology for this phase was not able to adopt a purist stance due to the overarching research questions across both phases; therefore, the researcher adopted a modified-Grounded Theory (M-GT) approach to account for these limitations. Thus, this research study is underpinned by pragmatism. This research paradigm allows the focus to be placed on selecting the best research tools, rather than being solely tied to specific approaches due to ontological and epistemological assumptions.

CHAPTER 4:
PHASE ONE

This chapter presents findings from Phase One of this doctoral research study. Phase One consisted of two stages. Stage 1 was a mixed-methods questionnaire (Sections 4.1 and 4.2) and stage 2, a semi-structured interview (sections 4.3 and 4.4). Section 4.5 utilises findings from all of Phase One of the study and draws upon literature from Chapter 2, along with additional literature that is more relevant in terms of the findings within this chapter, to create a proposed 'optimum science outreach model for sustained impact'. Each aspect of the proposed model draws upon primary data from the questionnaires and interviews, and secondary data within the literature, to provide a rationale for its design. The final section of this chapter considers what aspects of the proposed model needs further exploration within Phase Two of this study.

4.1 PILOT STUDY OF STAGE 1

Prior to conducting the pilot study, a pre-test was conducted with postgraduate students within the School of Education at LJMU (*n*=5), to elicit changes to the questionnaire, which are outlined in section 4.1.1.

4.1.1 PRE-PILOT OF STAGE 1

Bryman (2012) discusses how pre-testing and piloting is desirable to conduct before administering a self-completion questionnaire. This process allowed the researcher to have a dialogue with their participants and administer changes to the questionnaire design. This is crucial as once the questionnaire is circulated; the researcher no longer has control of this process. Cohen et al (2018) describe this as a practice that aims to increase reliability, validity and practicability of the questionnaire. The pre-test/pre-pilot asked the participants to identify any omissions or issues with readability and to ensure that the layout and the length of the questionnaire was appropriate. This enabled issues and flaws in the design to be rectified, in advance of the questionnaire's wider distribution. In this instance, the pre-testing was undertaken by PhD researchers within the School of Education (n=5). The questionnaire was modified to improve the questionnaire process; for example, question 3 was modified (see Appendix E: Example of completed questionnaire on paper and online) to have an 'other' option for the participant. Additionally, it was suggested that there were no questions that captured the demographic of the teachers who would complete the questionnaire. In retrospect, this is important as the experience of a teacher could influence their views. Other comments included the wording of some questions and the school specific language that had been used such as 'pupil premium' as a tool to measure SES. The feedback was implemented, and the questionnaire was modified at this stage to ensure that it would be accessible to all. Finally, prior to its wider distribution, the researcher facilitated tests for internal reliability on the questions, which used the Likert scale to further ensure validity. This process was discussed in detail in the previous chapter (section 3.4.2.4).

4.1.2 Findings from the pilot study

The pilot study was conducted using purposeful sampling of 15 teachers who taught at one high school in the north west of England. The researcher visited the school to distribute the paper questionnaire to the science department (n=9). Further participants (n=6) completed the online version of the questionnaire, as they were unavailable on the day.

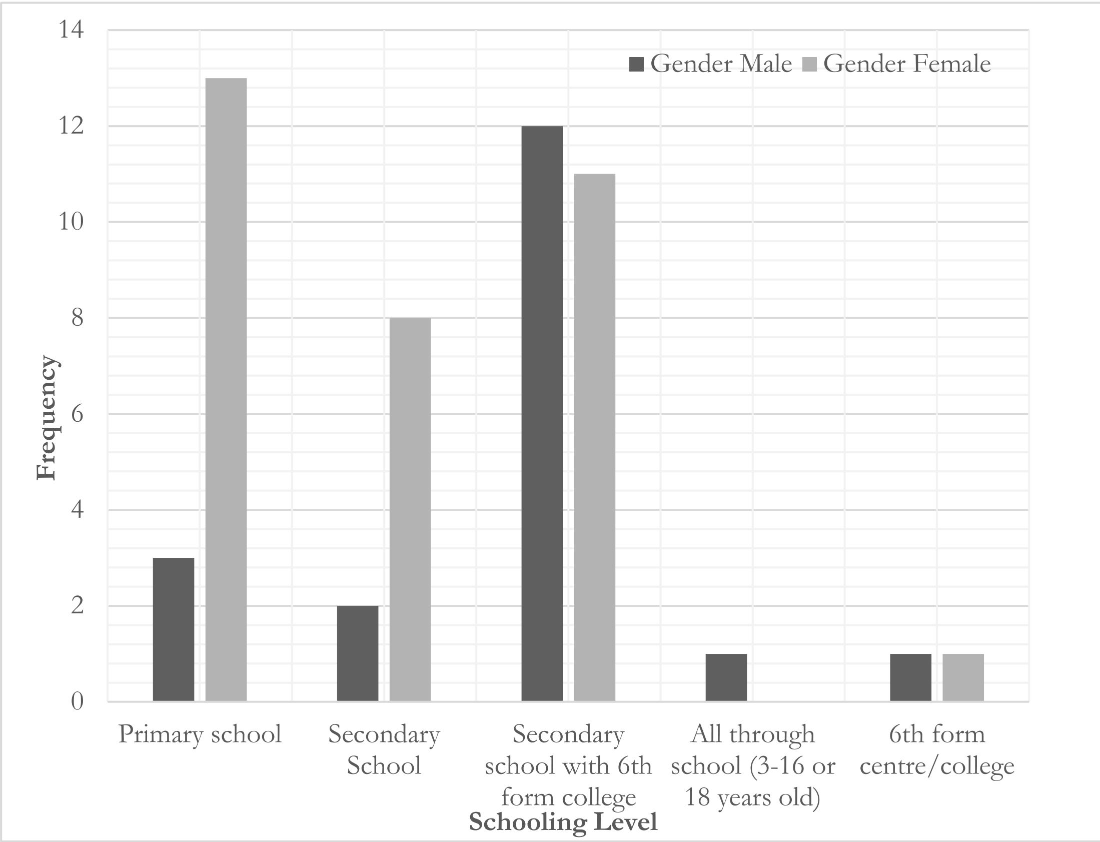
The analysis of this pilot data used all 15 participants (n=15), as the aim of the pilot was to quality assure the questionnaire in relation to the research questions. Although the analysis of this data was limited, due the small sample size, it provided descriptive frequencies, which reflected the literature. Some of these descriptive values could then be compared, and whilst no p-values were generated, trends occurred which could be explored more thoroughly in the main data collection process. The quantitative data from the pilot questionnaire, was coded and analysed using SPSS software, whilst the two open response questions were analysed using Thematic Analysis, using NVivo 11 (QSR International Pty, 2017) to assist with this process.

The data gathered from the pilot study did meet the objectives of the questionnaire Brennan, Mallaburn and Seton (2018) (see Appendix N: Summary of stage 1 pilot study). Participants were able to provide information regarding the types of science outreach activities that they had engaged with, share their beliefs about their perceived importance of these activities and provide comments, when appropriate, to enrich the data. These initial findings were able to generate hypotheses to focus upon during the main data collection stage and are explored in Section 4.2.1.

4.2 Stage 1: The questionnaire

Both the online and paper questionnaires were identical and were designed to remove barriers to participating in the research study. The response rate was relatively small (n=52), but this exceeds the "minimum of thirty cases", which Cohen et al (2018, p.203) identified to be able to undertake a statistical analysis in educational research, albeit still a low estimate. Greener (2011) suggests that assuming the sample size needs to be large is a misconception for this type of research; what is appropriate to consider is the purpose of the questionnaire and if the data collected (however large or small) represent the claims that the researcher is attempting to make. Bryman (2012) also indicated that many studies publish results where the response rate is low, and it is when these limitations are recognised and acknowledged within the research itself, that gives the information provided its credibility.

The mixed methods questionnaire aimed to understand the perceptions from teachers, across all educational levels in England, regarding what they considered science outreach activities to be, and their frequency in their educational establishment. The teachers within this study were from a range of schools, as indicated in Figure 4-1. 36.5% of participants were male, and 5.8% of these worked within the primary sector. Thus, the majority of the primary teachers in this study were female. The participants who taught in a sixth form college had an equal gender split. When considering how long the whole sample of participants had been teaching



for; 57.7% of these had been teaching for over 10 years and a third of these were male. 95.8% of all the participants worked in a state funded school or academy.

Figure 4-1 School level and gender of questionnaire participants

From the pilot study, the findings linked to four main areas: which groups of learners science outreach is beneficial to (pupil premium and gender); the age at which these programmes are most effective; the implementation; and finally, the design of the programme. These findings contributed to the generation of four null hypotheses which have been tested supported by additional data from Phase One, stage 1 of this study. Data generated allowed the researcher to determine whether the null hypothesis would be accepted or rejected, these are displayed in Table 4-1.

4.2.1 Quantitative results from the questionnaire

The quantitative analysis from the questionnaire reflects the hypotheses determined from the pilot study, these are presented in depth in the next sections. The summary of this is highlighted in Table 4-1.

Table 4-1 Summary of the outcome of each Null Hypothesis

Section	Null Hypothesis	Accept or Reject	Statistics tests used to determine this result	Modified Hypothesis
4.2.1.1	Teachers find that science outreach programmes are of no additional importance for pupil premium students.	Reject	Descriptive data, Spearman's rank correlation coefficient and effect size.	Teachers find that science outreach programmes are significantly important for pupil premium students
4.2.1.2	Teachers perceive no difference in the importance of Science outreach in relation to gender.	Accept	Descriptive Statistics and Mann Whitney-U test	n/a
4.2.1.3	Teachers perceive no difference in the importance of science outreach work at different educational levels.	Reject	Kruskal Wallis test, Friedman's, Wilcoxon signed rank test and effect size.	Teachers perceive a significant difference in the importance of science outreach work at different educational levels.
4.2.1.4	Teachers do not think there is any differences when it comes to their perceptions of science outreach work as a tool to 'motive, inspire and enhance' science in relation to the design, impact and implementation of these programmes.	Accept	Descriptive data, Wilcoxon's signed rank test and effect size. Then used Mann-Whitney U test to determine demographic difference in responses	n/a

4.2.1.1 The importance of science outreach activities for pupil premium students

Within this research study, one of the main foci is how science outreach experiences can impact upon students from a lower socio-economic background. According to Gorard and See (2008), students from this background, are less likely to continue into Higher Education, and if they do, are less likely to study a science. As previously discussed, due to an individual's demographic and home-life, they may miss experiences described by Morgan et al (2016) as an 'opportunity gap'; this is likely to lead to achievement gaps. Morgan et al (2016) discuss how opportunity gaps can begin before a child starts school, which impacts upon a child's science achievement at school, but also their understanding of public policies, reducing their potential to become scientifically literate adults. They also discussed how learners from lower socio-economic backgrounds, are more likely to attend a school in an area that is socially deprived (Morgan et al, 2016). This would infer that there would be fewer physical resources available and teachers who may have less experience of learners with a lower expectation. Therefore, science outreach activities are a means to close some opportunity gaps for these students but could also be as equally important for schools and teachers. Exploring teachers' responses to some Likert-scale questions (4f and 5f – see Appendix E: Example of completed questionnaire on paper and online) determined how teachers value these programmes in the context of this group of students and, to some extent, themselves.

The results from questions 4f and 5f, indicate that teachers felt they were important on both counts. 70.6% of participants outlined that they felt science outreach was 'A great deal' important for pupil premium students whilst 68.6% of the same participants 'strongly agreed' that outreach in science programmes provide experiences that the students may otherwise not have had the opportunity to engage with. These percentages are high and thus, outline the strongest positive option on the Likert Scale. When exploring the relationship here, Spearman's rank correlation coefficient was used to determine the relationship between the responses for the same population. The results are as follows:

> A Spearman's rank-order correlation was run to determine the relationship between 51 participants' response to questions regarding the importance of science outreach programmes for pupil premium students and the opportunities these outreach experiences provide. There was a strong positive correlation between Questions 4f and 5f, which was statistically significant as the r value is 0.591. The effect size was calculated as $r^2 = 0.349$

When using the interpretation of Kinnear and Gray (2004) as cited in Davis (2013), this indicates that there is a large effect size and therefore, the relationship between how the participants responded to each of these questions regarding social-demographics and science outreach programmes is meaningful. Therefore, this means that the null hypothesis can be rejected and modified accordingly (see The quantitative analysis from the questionnaire reflects the hypotheses determined from the pilot study, these are presented in depth in the next sections. Table 4-1). The summary of this is highlighted in Table 4-1.

4.2.1.2 The perceived importance of science outreach activities for male and female students.

In this analysis, the two questions which related to this theme were: 'How important do you consider science outreach work to be for girls' and 'How important do you consider science outreach work to be for boys'. A Likert scale was used to determine this level of importance, with 1 being 'not at all' and 5 being 'a great deal'; the respective means of these scores were 4.60 for girls and 4.52 for boys. The descriptive statistics indicate that all participants felt that it was of similar (high) importance to both genders. The researcher also wished to determine whether the gender of the participant had an impact on their response to this question. The Mann Whitney-U test was used to compare the responses between the two groups of participants, the results are as follows:

Question 4d: How important do you consider science outreach work to be for girls?

> A Mann-Whitney U test was run to determine if there were differences in Likert scale question scores for question 4d, between male and female participants. Distributions for the Likert scores for males and female participants were similar, as assessed by visual inspection. Likert scores for male participants (mean rank = 28.24) were not statistically significantly higher than for female participants (mean rank = 25.50), U [Mann-Whitney U score] = 280.500, z [standardised test statistic] = -0.761, p [significance level] = 0.447. The effect size when calculating η^2 using the z value =0.011. This is a small effect size when using Cohen's (1988) interpretation.

Question 4e: How important do you consider science outreach work to be for boys?

> A Mann-Whitney U test was used to determine if there were differences in Likert scale question scores for question 4e, between male and female participants. Distributions of the Likert scores for males and female participants were similar, as assessed by visual inspection. Likert scores for male participants (mean rank = 26.34) were not statistically significantly lower than for female participants (mean rank = 26.59), U [Mann-Whitney U score] = 310.500, z [standardised test statistic] =-0.066, p [significance level] = 0.948. The effect size when calculating η^2 using the z value =0.000. This has no effect size when using Cohen's (1988) interpretation.

Therefore, the null hypothesis may be accepted, as the results do not indicate that participants, regardless of their own gender, believe there to be a difference in the importance of science outreach work for male and female students.

Within the literature, there is a strong indication that when it comes to the physical sciences there is a 'leaky pipeline' when it comes to females (Gouthier et al, 2008; Harsh, Maltese and Tai, 2012; Ivie and Langer-Tesfaye, 2012). Mujtaba and Reiss (2013) discuss that females were statistically less significant to receive encouragement from their teachers and had a less positive experience of physics lessons when compared to males. These findings may provide a reason as to why there could be fewer females who study physics than males, so it is important when considering target demographics to engage as part of science outreach programmes. If it is the case that girls do not have as much encouragement compared to their male counterparts then these additional experiences may provide role models who can relate equally to all genders. Therefore, teachers' views about the importance of science outreach programmes for males and females could reflect their own habitus towards genders in science.

4.2.1.3 The importance of science outreach activities at different educational levels

Wilson and Chizeck (200) outline that outreach programmes are often targeted at older students, as the provider is a University engaging in their widening participation programme. Koehler, Park and Kaplan (1999) agree as they find that the natural curiosity surrounding science is often dampened as early as middle school (7-13 years old) and therefore science outreach interventions are more effective with younger students to maintain and nurture their natural curiosity.

Dubetz and Wilson (2013) describe an outreach programme that is specifically for middle school aged girls entitled 'Girls in Engineering, Mathematics and Science (GEMS)'. Whilst it is noted that this is a gender specific outreach programme, it has carefully considered the age of its students using data from Trends in International Mathematics and Science Study (TIMSS) science scores in USA (2007). It was found that at 4th grade (a 9–10-year-old) the scores indicate that there is no significant academic differences between girls and boys scores, compared to a 12% difference at 8th grade (a 13-14-year-old), where male students score higher (TIMSS, 2007). This means that between the ages of 9 and 14 something impacts upon the respective achievement of girls and boys in science. The GEMs programme focused on 6th grade students (11–12-year-olds) as a result of these findings as a hope to narrow the gap (Dubetz and Wilson, 2013). MacLean (2017, p.58) agrees and considers 7th and 8th grade (12–14-year-old) to be a "critical juncture at which girls' performance plummets and no longer echoes that of the boys." Thus, to support these issues in formal science education and to have the most impact, they need to be aimed at younger aged students.

These discussions are common in relation to the 'age' at which to target science outreach programmes to have the most effect. Thus, the analysis of teachers' perceptions of the importance of science outreach activities at different educational levels, were explored to determine if the participants did show any bias in relation to different educational levels. The descriptive tests were used to provide a mean of the Likert Scale score for the three questions which asked 'how important do you think science outreach is at…' the three different educational levels in the UK (primary/secondary/sixth form college level). Whilst there is controversy regarding using Likert scale scores as ordinal data, the researcher is aware of the caution behind reporting statistical averages and the mean values generated are used as a measure to compare attitudes. The mean score for the importance at primary level (mean=3.88) was visually lower that the scores for secondary level (mean=4.56) and sixth form college (mean=4.52). However, to compare if there was a statistical significance between these values, the Friedman's t test was applied, as the same population of participants provided a response to their views of outreach activities over three different time periods. The Wilcoxon's signed rank test was used post-hoc, to measure the difference between each two groups. The findings are as follows:

> There was a statistically significant difference in the perceived importance of science outreach at different educational levels and the Likert scale score of the participants n=51, $\chi^2 = 27.045$ Test Statistic, $p = 0.000$ Asymptotic Sig. (2-sided test) value. Post hoc analysis with Wilcoxon

signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.017$. Median (IQR) perceived importance of science outreach at primary, secondary and sixth form/college level were 4.00 (3.00 to 5.00), 5.00 (4.00 to 5.00) and 5.00 (4.00 to 5.00), respectively. There were no significant differences between the perceived importance of science outreach at secondary and sixth form/college level (Z = -1.789 p = 0.074). However, there was a statistically significant reduction in perceived importance between secondary level and primary level (Z = -3.999 p = 0.000) and Sixth form college and primary level (Z =-4.098 p = 0.000).

The effect size when calculating η^2 using the Wilcoxon values for each pair and were interpreted using Cohen's (1988) interpretation. The results between primary and secondary, Wilcoxon signed rank test = 0.000, effect size = 12.117 (large), between primary and sixth form centre/college, Wilcoxon signed rank test = 0.000, effect size = 12.117 (large) and between secondary and sixth form college level, Wilcoxon signed rank test = 0.74, effect size = 12.114 (large).

Thus, the participants felt that science outreach was significantly less important for primary school aged students compared to the higher educational levels. However, when comparing effect sizes, although there was no significant difference between participants' responses, the effect size is large. This means that there is a strong positive correlation between how the participants responded positively towards their perceived importance of these questions. When further considering this data, which considers the teachers as 'one' population, it was necessary to explore whether the school in which the participant taught, may have an impact upon these perceptions. Therefore, the Kurskal-Wallis test analysed whether the school type of the participant had an impact on how they responded to each question regarding the importance of science outreach. The results are considered as follows:

The perceived importance of science outreach at primary school level and school type of the participants:

A Kruskal-Wallis H test was run to determine differences in Likert scale scores of the perceived importance of science outreach at primary school level between participants who taught at different school levels: "primary school" (n=16), "secondary school " (n=10) and "secondary school with a sixth form college" (n=22). Distributions of the perceived importance for science outreach at primary level scores were similar for all groups, as assessed by visual inspection of a boxplot. The distributions of the perceived importance of science outreach between participants who taught at primary school level are not statistically significantly different between groups, χ^2 (2) = 2.132, Test Statistic, $p = 0.344$, with a mean rank score of 21.88 for primary school, 22.15 for secondary school and 27.40 for secondary school with a sixth form college.

The perceived importance of science outreach at secondary school level and school type of the participants:

A Kruskal-Wallis H test was run to determine differences in Likert scale scores of the perceived importance of science outreach at secondary school level between participants who taught at different school levels: "primary school" (*n*=16), "secondary school " (*n*=10) and "secondary school with a sixth form college" (*n*=23). Distributions of the perceived importance for science outreach at primary level scores were similar for all groups, as assessed by visual inspection of a boxplot. The distributions of the perceived importance of science outreach between participants who taught at secondary school level scores are not statistically significantly different between groups, $\chi^2 = 0.362$, Test Statistic, $p = 0.835$ with a mean rank score of 23.69 for primary school, 24.50 for secondary school and 26.13 for secondary school with a sixth form college.

The perceived importance of science outreach at sixth form centre/college level and school type of the participants:

A Kruskal-Wallis H test was run to determine differences in Likert scale scores of the perceived importance of science outreach at sixth form centre/college level between participants who taught at different school levels: "primary school" (*n*=16), "secondary school " (*n*=10) and "secondary school with a sixth form college" (*n*=23). Distributions of the perceived importance for science outreach at sixth form centre/college level scores were similar for all groups, as assessed by visual inspection of a boxplot. The distributions of the perceived importance of science outreach between participants who taught at sixth form centre/college level scores are not statistically significantly different between groups, $\chi 2 = 0.531$, Test Statistic, $p = 0.767$, with a mean rank score of 23.25 for primary school, 25.20 for secondary school and 26.13 for secondary school with a sixth form college.

Therefore, based on both statistical analysis of the difference between means of the score on the Likert scale, the effect size and comparing whether the school level the participants taught at, the null hypothesis should be rejected. The new hypothesis is outlined in Table 4-1.

4.2.1.4 Teachers' perceptions of the potential of science outreach programmes to inspire students and have a sustained impact.

This hypothesis explored teachers' perceptions of science outreach programmes and whether their views differed regarding the potential for outreach activities to 'enthuse, engage and inspire' students, compared to whether they had an impact upon their students' future career choices and learning in science. To test this null hypothesis the questions were divided into either, motivation and inspiration for science outreach activities, or to the design, implementation and impact of the programme, outlined in Table 4-2.

Table 4-2 Categorising the nature of the statements from Question 5 in the questionnaire

Category of questions	**Questions linked to the potential of science outreach programmes to increase engagement and enjoyment in science.**	**Questions linked to the quality of the science outreach programme and its lasting impact.**
Questions	Science outreach work motivates students to apply for science courses at university.	Science outreach programmes are valued as an intervention tool within school/colleges to raise attainment in science.
	Pupils who are involved in science outreach programmes are more likely to enjoy science.	Science outreach work enriches the science programmes of study within my school/college.
	Outreach work in science helps to enhance pupils learning in their everyday science lessons.	Science outreach work has a lasting impact on students involved within this programme.
	Science inspires students to consider science careers they may not otherwise have thought about.	Outreach programmes in science allow pupils to experience activities they may otherwise not have the opportunities to do so.

To be able to analyse if there was a statistical significance, the participants' overall responses to these two groups of questions were compared using the Wilcoxon signed rank test as the population was the same. The results are below:

> A Wilcoxon signed rank test showed that participants' responses to the different groups of questions regarding perceptions of science outreach programme increasing the positive experience of science did not elicit a statistically significant difference

> between perceived ideas about the implementation and impact of these science outreach programmes (Z = -0.746, p = 0.456). Indeed, median score for both groups of questions was 4.00. The effect size when calculating η^2 using the Wilcoxon values for each pair and interpreted using Cohen's (1988) interpretation was 12.696 (large).

This means that there was a strong positive relationship between how the participants answered these two groups of questions, but there were no significant differences between these two values and thus the null hypothesis was accepted.

Whilst there were no significant differences between perceptions of science outreach activities to inspire and motivate students in science compared to the programmes' ability to have an impact upon the students, there was a difference in the perceived importance at different educational levels (Section 4.2.1.3). Each question outlined in Table 4-2 was analysed using the Mann Whitney U test and the Wilcoxon signed rank test to identify whether the participant was a teacher at a primary school and if this impacted upon their response. The results outlined there was no statistical significance between responses from participants for all questions apart from the question which asked, "Outreach work in science helps to enhance pupils learning in their everyday science lessons". The results for the analysis of this question is as follows:

> A Mann-Whitney U test was run to determine if there were differences in Likert scale scores for Q5a between participants at primary or non-primary schools. Distributions of the response to Q5a for primary and non-primary participants were different, as assessed by visual inspection. Median engagement score was statistically significantly different between participants at primary school and non-primary schools, $U = 191$, $z = -2.061$, $p = 0.039$.

This means that primary school participants agreed more strongly that outreach work in science helps to enhance pupils learning in their science lessons. This links to several ideas surrounding the lack of teacher confidence in teaching science to younger learners and the use of these programmes to assist with the learning (Wellcome Trust, 2017).

Linking these ideas to other research findings, Bouge et al (2013) discusses how similar outreach programmes in engineering that were designed to have an impact on recruitment of minority groups into engineering degrees, have not had the desired effect. For example, although the number of Hispanic women in the USA grew from 1.6% to 1.8% choosing an undergraduate degree in STEM, the number of black women decreased from 1.7% to 1.3% (NSF, 2012). It is discussed how the low percentage increases do not reflect the cost and time invested into the STEM outreach programmes; it was perceived as a small return for the millions of dollars invested into programmes designed to encourage individuals to choose to enter and continue in engineering (Bogue et al, 2013). This notion is similar in science focused outreach programmes, where students do enjoy these events, but the desired impact is questionable (Banerjee; 2017; Gall et al, 2020). There is also a more sinister notion regarding the rationale for universities providing outreach programmes, the schools which are targeted and the quality of the programmes' provision (Rich, 2012). Some question whether it is to assist in engaging those underrepresented demographics, or in fact it is to recruit and target students to come to their institution; thus, viewing outreach as a business opportunity and not WP (Cridge and Cridge, 2015; Rich, 2012). Regardless of intentions, outreach interventions in science continue. As research into the field develops, there is more guidance on how to make these programmes cohesive, such as: fostering an effective partnership between the school and those who deliver the activities and allowing time for these partnerships to develop (James et al, 2006). It is also noted by Glover et al (2016) that research within the field does not often focus on the reasons teachers chose to engage with these programmes or the impact teachers can have upon students by engaging with a longitudinal programme.

4.2.2 QUALITATIVE RESULTS FROM THE QUESTIONNAIRE

The responses from question 2 (*n*= 46) and question 6 (*n*=43) within the questionnaire allowed participants to provide an open response to their ideas of what science outreach is. These were both collated from each individual questionnaire and analysed using Thematic Analysis (TA) in NVivo (QSR International Pty, 2017). Six themes had been predetermined from the literature review, and three more emerged from the TA of the questionnaire closed responses. The rationale for this has been explained in Chapter 3, but the themes are summarised below in Table 4-3 in section 4.2.2.1. Question 2 was near the start of the questionnaire and participants had not had the opportunity to reflect on their experiences and perceptions of these programmes at this point. This meant that responses to this first open response question was brief and sometimes identified how initially teachers were not fully aware of what the term science outreach meant. This is highlighted by this response (30P) "I don't fully understand 'science outreach' work. I would imagine it is independent agencies coming in to work with small groups of children/classes." However, question 6 allowed teachers to add additional information and extend their ideas enhancing the information they had previously shared, and this led to new codes being generated that were only populated by information from question 6.

The structure of the presentation of the results from the questionnaire, reflect the initial pre-determined or emergent themes. This section is brief in nature, as these responses were the starting point for the TA of the interviews in Stage 2. Therefore, the themes are discussed in further detail in Section 4.4 and also include examples of clear findings from the questionnaire. This holistic approach to the TA of both the questionnaire and interview responses were chosen, as the generation of the initial model required more in-depth responses from the participants than just the data generated from the questionnaire.

4.2.2.1 Pre-determined themes

There were six pre-determined themes informed by literature which are summarised in Table 4-3. These themes were selected from two secondary resources; Cridge and Cridge (2015) who focused on the evaluation of how universities engage school students, and Gumaelius et al's (2016) review which looked at eight different European (EU) science outreach initiatives. The two papers were a pivotal start for the formation of the research questions and directly relate to the aims of this research. These pre-determined ideas were outlined before the data collection process and assisted with developing the questionnaire itself, and therefore, it was anticipated that these themes would be present in the data collected.

The first two themes encapsulate participants' ideas surrounding the positive impacts engaging with outreach activities may have upon learners (Theme 1) and why they may differ from regular science lessons (Theme 2). These are often supported by examples of how these may occur (Theme 5) as there are many references which overlap; for example, participant 10S's response is used within two different examples in Table 4-3. This response highlights important stakeholders in an outreach programme, the provider (outsourced member), the school and the learner. These ideas are supported by the response to the same question by participant 11S who believes it is "universities sharing their knowledge and passion with school children, in the hope to inspire and encourage further studies in science". It was also highlighted that teachers were important stakeholders as participant 20P highlighted that it "Inspires pupils in the subjects, engages them in learning, supports teacher CPD and confidence".

The idea of the teacher being supported by these endeavours is a key category that is highlighted by Jeffers et al. (2004) who considered six features that were found to be common for the 59 US outreach programmes that were included in their pedagogical framework study. This framework was used by Gumaelius et al. (2016), as a source of reference when comparing eight EU science outreach programmes. It is encouraging to note that there is a global alignment here between teachers across the Atlantic with teachers in schools in the north-west of England. One of these features outlines how outreach programmes can include 'instruction for teachers', which has wider benefits. Constan and Spicer (2015) discuss how these experiences for teachers lead to more effective instruction for their students.

When considering who provides these outreach experiences, other schools may be the provider of these activities according to participant 38P who states, “links with secondary schools, e.g., Year 6 and various individuals/companies delivering workshops”. This is supported by a secondary teacher (Participant 28S) who comments that “as a member of the science department I am involved in about 5 (yearly) sessions that our high school runs for local primary schools. These sessions focus on fun science and getting the KS2 kids involved with practicals within the science laboratory”. This response aligns several primary teacher participants who describe how science outreach is engaging and inspiring, as it provides an alternative experience to an ‘ordinary’ science lesson. Participant 40P highlighted how “It should be more stimulating and dynamic than an ordinary lesson.” Participant 38P agrees as these experiences “help children to engage through stimulating activities that are usually difficult to deliver in a classroom setting”. These ideas were also acknowledged by secondary school Participant 22S who stated that science outreach was “providing and promoting science to other schools who may not have the facilities to do so”. Participant 19S also highlights that as a secondary teacher, these outreach experiences are still about “Experiencing science beyond the classroom. Specialist instructions. Vocational where appropriate”. The ideas of the experiences being a partnership, and different institutions are summarised in Participant 27S’s response to question 2:

> Teaching ‘students’ that you wouldn’t normally teach/provide resources for, e.g. Primary students visiting a secondary school and having a science lesson—E.g. 6th form students visiting a chemistry laboratory at a university. E.g. Secondary science department loaning equipment to a primary. E.g. Science technicians providing support/training for primary school teachers. (Participant 27S).

Table 4-3 A summary of the predetermined themes with examples from the data

No.	Theme	Sub-theme	Description	Verbatim example
1	Outreach work inspires learners and promotes engagement and confidence in science.	Enthuse and engage	Any reference to students being engaged and enthused in science.	"It is most important to enthuse children about science." (Participant 18P)
		Inspiration and motivation	Any reference to providing inspiration.	"Outreach in science provides the pupils with the context to become inspired by their current learning." (Participant 10S)
		Confidence in science	Any references that suggest students feel more confident about science.	Give pupils more confidence in their abilities on the subject." (Participant 22S)
2	Outreach allows hands-on access to different resources and types of activities.	Access to resources not available in schools.	Suggestions that it allows students to experience activities that would not happen in an everyday classroom.	"It helps children to engage through stimulating activities that are usually difficult to deliver in a classroom setting." (Participant 38P)
		Exemplifies applications of science.	Reference to outreach being 'hands-on'	"It should provide something different/more exciting/more dynamic or more detailed than an 'ordinary' lesson or teacher of primary science can provide." (Participant 42P)
3	Outreach provides a wider knowledge of careers available in science.		Reference to how outreach can allow students to find out about different careers available in science.	"Great to give alternative career ideas." (Participant 32S)
4	Outreach work shows how science is applied in a real-life context.	Place's learning science in context.	Any reference to science in context.	"Important to raise profile of science and its relevance to life outside/beyond education." (Participant 33S)
		Exemplifies applications of science.	Any reference to the uses of science in everyday life.	"Any activity that gets pupils/student applying/linking their scientific knowledge must be worthwhile." (Participant 6S)
5	Science outreach involves external partners	Inbound experiences	Any description of a person or organisation visiting the school to deliver an outreach activity.	"Outsourced members of the scientific community coming into schools". (Participant 10S)
		Outbound experiences	Any description of students visiting another location (outside of school) to engage with science activities.	"Taking students to university and industry to see career pathways and application of their learning." (Participant 39F)
6	Outreach includes continued professional development (CPD) for teachers'		Reference to how science outreach work may support teacher development.	"Career fairs, work experience placements, up to date training/support for teachers." (Participant 3S)

This references links to Themes 1, 2, 5 and 6 and outlines a dynamic equilibrium that is supportive of each other. The idea of partnership is key to establishing effective science outreach programmes. Goodman (2002) describes how outreach programmes benefit not only the students and their teachers, but also the scientists involved learn pedagogical techniques from the teachers to improve their own delivery. It is also mutually beneficial for the institution delivering these programmes as the activity space (such as a university) provides a fun and unique learning environment for the students and teachers, but in turn, the reputation of the university or secondary school is enhanced.

Science outreach programmes are also described by 15 of the participants as an outlet to promote careers in science as participant 39F shares their experiences of "taking students to university and industry to see career pathways and application of their learning". Whilst most of those who discussed this were from secondary school or FE, it was still highlighted by two primary teachers; participant 35P described how science outreach "encourages children to think more about how they could achieve a career in science". This means that even younger students are being encouraged to consider careers and thus verifies aspects of section 4.2.1.3 regarding the age range at which these programmes are aimed. Theme 3 and Theme 4 overlap somewhat as participant responses often highlighted how science outreach "Gives information of careers in science and real-world scenarios" (Participant 31S) or "Shows how the science has application in real life, what jobs are available now and what jobs might be available in the future" (Participant 12A).

Science outreach programmes can take place in schools or outside school grounds and are flexible in their approach (Gall, Vollbrecht and Tobias, 2020). Participant 10S describes how science outreach programmes could be "outsourced members of the scientific community coming into schools" or Participant 39F felt it could consist of "taking students to university and industry to see career pathways and application of their learning". Whilst the outreach activities may vary in location; participations discussed how these should 'add value' to the learners' experience. Whereby it should extend learning beyond the classroom and place it in the context of the 'real world' to make the experiences more relevant and memorable (Vennix, Den Brok, and Taconis, 2018). Participant 40P described how "it should be more stimulating and dynamic than an ordinary lesson", and Participant 42P adds that "it should provide something different/more exciting/more dynamic or detailed than an 'ordinary' lesson or teacher of primary science can provide". Teachers also discuss outreach programmes as being able to provide an aspect of science that is not available in schools. They discuss how it is a tool to raise the profile of science, provide relevance to science learning and take learning outside the limitations of the classroom. It is discussed by participant 11S who states how "it takes learning outside the limits of the classroom and into the real world. This makes the learning relevant to the students and makes it something that the students would remember".

These findings match similar results from Glover et al. (2016) who interviewed teachers regarding their involvement with a long-term chemistry outreach programme with a university in England. Teachers discussed how these experiences allowed the students to relate chemistry to 'real-life' and how it could allow students to consider chemistry related careers. The teachers as part of the study also mimicked some of the comparisons between what they can do and what institutions can do as one teacher from the study stated "chemistry at school compared to chemistry at university…well it's just so different" (Glover et al., 2016, p.85). Comparing the responses of teachers in this study to one looking at similar ideas in the South-West of England increases the confidence of the study, as it shows that teachers have similar thoughts nationally. It also adds to the validity of the pre-determined themes as they reflect published findings by other authors. The process of having themes that were anticipated helped with the initial coding of the responses and provided a focus when initially reviewing these. However, there were some codes that did not fit these themes, and these are discussed below.

4.2.2.2 Emergent themes

During the coding process, the responses to the open questions on the questionnaire indicated that not all these reflect the predetermined themes that had been outlined from the two papers in the previous section. These emergent themes are summarised in

Table 4-4 on the next page and outline some of the more pragmatic issues related to outreach programmes and link to aspects within the literature regarding science outreach activities adding 'food for thought' to designing an outreach model in Section 4.6.

Table 4-4 A summary of the emergent themes with examples from the data

No	Theme	Sub-themes	Description	Verbatim example
7	Science Outreach assists with learning in the curriculum.		Any reference to outreach activities supporting formal learning that is prescribed by the curriculum.	"We have had a number of organisations visit our school over the past 10 years. All experiences have excited our children and supported teaching and learning." (Participant 37P)
8	Issues related to the logistics and design of delivering outreach work.		Any reference to the design or cost (either time or financially) of engaging with outreach in science.	"Usually this seems to take place as 'one off' days" (Participant 12A)
9	Not all students will respond to science outreach programmes in the same way.	Science outreach is able to support and enthuse specific groups of learners.	Reference to how outreach work may be particularly useful for particular types of students.	"Any activity which engages 'non-scientists' in a scientific activity." (Participant 26S)
		The impact of outreach work is dependent on each particular student.	Suggestion that science outreach work may appeal to some students and not to others.	"It can motivate but it depends upon whether the students involved are enthusiastic" (Participant 28S)

Theme 7 discusses how participants described how they felt that science outreach programmes can support learning, as Participant 24S reflects that it is about "universities, colleges, schools or industry making wider links with groups of individuals to promote, enhance and support the learning and understanding of science". The idea of science outreach programmes enhancing the learning in science links to discussions regarding Themes 2, 3 and 4 and indicates how the activities should add value and context to the learning process. This is explained by Participant 43P, who described how "science outreach should supplement the high-quality science teaching of the class teacher… or provides the opportunity to complete task/work with resources not available in school." These responses demonstrate how teachers want these experiences to be new and exciting, but also purposeful. Seton, Mallaburn and Goodwin (2018b, p.29) described how teachers within their study produced similar responses and were keen that these outreach experiences would "enrich them [the students] beyond classroom experience." However, supplementing learning did not always occur as Participant 27S outlines that it is only valuable "when well organised, outreach programmes are a valuable part of the extended curriculum". This response indicates that some programmes they have experienced may not have been structured purposefully, and if this is the case, then the effect of these programmes may be limited.

Shaw, Harrison and Shallcross (2010) concluded that there is no doubt that the students enjoy their chemistry outreach events but the desired outcomes of the activities, linked to impact, is less evident. Teachers were asked about why they got involved with a chemistry outreach programme, and participants from Shaw et al.'s (2010) study suggested that they wanted these activities to assist with the learning in science which reflects similar ideas identified by participants in this study. However, it was found that only one teacher out of the eight interviewed provided an example of how the programme had impacted on their student's learning. These reflect similar findings of Luehmann and Markowitz (2007) as they also found that teachers described the learning outcomes as the desired benefits of the programme, however, feedback post-event linked to how motivated their students were.

The aims of many of these programmes were to encourage learners to consider science in the future, but Participant 8S outlines their thoughts that "outreach is welcomed by pupils, but mainly as a day out. Outreach is valued by those already interested in science." Thus, it was also postulated by the teachers who completed the questionnaire, that science outreach programmes are not for all students as Participant 23S finds that "it is very pupil dependent. If a pupil already has a strong interest and career pathway in science/another subject, it has no impact. Equally, if a pupil has no interest in science, it has no worth." This level of uncertainty suggests that whilst this teacher feels these science activities may be worthwhile; they are potentially not for everyone. Glover et al. (2016) discuss similar findings in their study as they also summarised that if groups of students are keen, they will potentially gain significantly from outreach activities and that their responses may depend on their inherent science ability. This discussion regarding how different students may respond to these programmes is described by Shanahan et al. (2011) who conclude in their research about an elementary science outreach programme, that all students responded positively to the programme. Participant 13S agrees as they state that "I think it's a great idea as it focuses on applications of learning and can increase interest or extend high ability pupils".

Probably, the most insightful emergent theme that arose from the questionnaire is that which links to ideas about the design of the outreach programme, or the logistics of being involved with these 'extra' science activities. Many of the responses from the participants reflected a level of caution when it came to describing these programmes, such as "it's an excellent motivational tool if used effectively with the right students" (Participant 15S) and "it's a great thing, but it needs to be thought out more and embedded into the schemes of work and integrated into the curriculum" (Participant 5S). This is useful information which can be reflected upon and inform the future designs of these programmes. One teacher discussed the utility of these programmes by stating the need for outreach activities to be organised and delivered effectively. There are also logistical concerns such as money and time. Participant 1S highlights that "engaging, good quality outreach experiences are very valuable for motivating students and good quality learning. The danger is that, as teachers are so overworked, the activities become forgotten". This centres the teacher as an important stakeholder in relation to the design of the outreach programme in science, to assist with its impact. Goodman (2002) also reviewed the benefits and limitations of partnerships between universities and schools in this context. Whilst the positives replicate many responses from the teachers in this study, the practicalities of time and money are also key issues for the HEIs, and not the schools alone.

4.2.3 Stage 1 Summary

The mixed-methods questionnaire was designed to explore teachers' perceptions of science outreach programmes and the QUANT: qual analysis provided an important focal point for exploring the research questions of this study. The analysis outlined that science outreach was considered more important for older students, which reflects concerns from the literature regarding the age at which these programmes should be targeted (Constan and Spicer, 2015). However, there was no gender bias for the importance of these science activities for male and female students. T was a positive correlation between participants' views regarding the importance of these activities for pupil premium students and the unique opportunities they provide. This was further explored during the TA of the two open questions.

The responses from participants to the open questions provided detailed information regarding teachers' experiences and ideas of what science outreach was, a visual summary of these responses are shown in Figure 4-2. There was a skew towards the positive aspects of these activities, whilst the negative or cautious comments focused on teacher workload and how different groups of students may respond to these programmes. The participants outlined how science outreach programmes often go beyond the 'ordinary' science lesson, and they value them being a tool "making school science more relevant to the world of work" (Participant 7S). Therefore, it is to be concluded that science outreach programmes are a worthwhile endeavour, even though the questionnaire indicated that 5.9% of participants 'never' engaged with science outreach programmes and 25.5% of participants only did so once or twice a year. Participant 36P supports these findings as they claim "it is needed more for all children of all ages. I feel children do not have enough of this in schools". The next stage is a continuation of the TA from Stage 1. The participants for this study were purposefully selected to provide further information regarding their experiences and views of science outreach activities. The results and process are discussed in the subsequent sections.

Figure 4-2 Word cloud of open-ended responses within the questionnaires

4.3 THE PILOT OF STAGE 2

The pre-test of Stage 2 was used as an exercise to ensure that the interview questions and responses gathered, would produce meaningful data. A pre-pilot (or pre-test) of the questions allowed two participants, who were high school teachers in the NW of England, to answer the questions and comment on the process to inform amendments. Following the analysis of the pre-pilot exercise, there were several modifications to the design of the interview schedule. The participants discussed the purpose and structure of each question and provided feedback which would improve the quality of data gathered. The findings provide specific examples of science outreach work in the participants' own school and their motivation for engaging with outreach activities. Following this feedback, the interview questions were again piloted with another teacher from a different NW school (*n*=1) to validate the changes made. There were no further amendments, and therefore this teacher's response was included and discussed in the main stage of Phase One, Study 2.

4.3.1 PRE-TEST

As previously discussed within Chapter 3 (Section 3.5), an effective interview should anticipate typical responses so that data generated that will correspond to the research objectives (Cohen et al., 2018). Thus, the pre-test/pre-pilot process was a crucial stage to ensure that the research objectives were achieved. This pre-pilot interview, was completed with two secondary science teachers (*n*=2) who attended the Salter's Chemistry Festival. They were purposefully selected as they were attending a science outreach activity and therefore could provide an informed response. The intended research outcomes were explained to these participants and how their views could inform the doctoral study. They were also made aware that this was a pre-pilot and therefore, after answering the questions they would be asked whether the questions had sufficiently scaffolded their thought processes, what further questions might be conducive to the study and the designated timeframe allocated to the questions. This process was not audio recorded, but interview schedules were annotated and field-notes were completed immediately after the interview. This allowed the researcher to record the suggestions and feedback from the participants.

4.3.2 FINDINGS FROM THE PRE-PILOT STUDY

The findings from this process resulted in amendments to the design of the interview schedule. The rationale for these changes is provided below and in Appendix G: Interview Schedule and Appendix H: Pre-pilot Interviews notes and changes to be made. The first section of the interview involved a sequence of closed response questions to ascertain the current science outreach programmes the teachers engaged with, whilst the remainder was semi-structured, to allow participants (*n*=2) to respond more freely. Although there were two participants for the pre-pilot interview activity, the responses are presented collectively as 'one voice', as this was a group interview. Cohen et al (2018) explain how this ensures that no individual is unnecessarily marginalised.

4.3.2.1 Section 1 Feedback and discussion

Section one of the interview questions contained one question that had 15 sub-questions regarding the outreach activities schools partake in. It was suggested that the questions in this section needed to be plural to allow participants to discuss their different endeavours. To be able to accommodate this change, the researcher would need to review the schedule 'notes' sheet to ensure each question was aligned to a particular outreach programme, to reduce confusion when reviewing the notes post-interview. Question 1 contained closed response questions. However, during the pre-pilot when the participants were answering the questions, they tended to expand upon their experiences. Thus, as was likely to appear in the main data collection process, the expected timeframe for the interview was reviewed and the subsequent participant information sheet updated. It is important that participants have a realistic timeframe for the interview to ensure that they are informed prior to engaging in the research (Cohen et al., 2018).

When reflecting upon the responses from the interview, the participants emphasised the opportunities science outreach provides for pupil premium students. They provided outreach examples and highlighted that these were mainly delivered by companies or universities as part of their WP programmes. The participants explained how the activities utilised resources that were not available in a school environment and delivered as a workshop format where pupils were 'invited' to attend. Although the participants thought these activities useful, they were also keen to state how they would never "force the students" to go to an event. This is reassuring in relation to school spending their Pupil Premium fund, as funds are utilised to provide experiences that may otherwise not be possible; hence, inspiring and engaging 'disadvantaged' learners (Ofsted, 2013; EEF, 2019). However according to Gorard et al (2019), it is not necessarily positive, as 'disadvantaged' students who do not meet the 'pupil premium' criteria, can be excluded from these events.

4.3.2.2 Section 2

Section 2 of the interview contained open response questions, with 'prompts and probe' questions to encourage a response. The pre-pilot interview process highlighted that some of these questions were not well designed as they asked two different things within one question. For example, Question 2 was rather long, and it was determined that it should be divided into two sections, to ensure that the response was not limited. Similarly, Question 3 asked 'the negative effect science outreach programmes may have on pupils' and 'what may 'limit' a teacher's engagement with outreach programmes'. By 'splitting' the questions to simplify them, it also reflected the participants' suggestions to add an additional 'stand-alone' question that asked about why teachers may not want to/be able to attend or utilise outreach activities. Question 4 asked teachers what would they keep the same regarding the science outreach programmes they had encountered and allowed them to consider what they would do if they were leading similar outreach activities. At times, there was confusion when the participants started discussing multiple outreach activities; thus, it was decided to amend the interview schedule to allow participants to discuss each experience discretely.

In their responses, the participants highlighted the perceived benefits of the outreach programme bringing new opportunities to pupils to learn about future career prospects. For example, a participant identified that some pupils had never been to a university campus before (the child's parents had not attended university) and that it provided an insight into what they could potentially achieve. In addition, what was also stressed was the notion that these programmes 'make science real' for the learners. When the participants were asked whether the benefits were long-lasting, they discussed how they would like to think they were, but 'follow up' activities in school were often neglected, due to time constraints within the curriculum. Both participants discussed an outreach programme they engaged with called 'Chemistry for All'; which was a longitudinal science outreach project funded by the Royal Society of Chemistry (RSC, 2020). They both discussed how they perceived this science outreach activity having a longer-lasting impact, but they did state it was pupil dependent. The points highlighted aligned with discussions in the literature regarding the impact of, and the length of outreach programmes. The Department for Business, Innovation and Skills (DBIS) (2014) highlighted that long-term, sustained outreach programmes are crucial to success in widening participation agendas in HE. The participants did state that if the outreach activity was pitched at the wrong level or delivered in the wrong style, this would result in disengaged pupils. The participants discussed how could then have a detrimental effect if the pupil did not enjoy science, but if it was eluded to that the outreach event would be an enjoyable experience and if it wasn't then this could 'reaffirm' to these individuals their dislike for science.

The final question asked the participants to reflect upon the interview experience. Gillham (2005) outlines how this process allows for further development of the design of the interview schedule. When asked about the length of the interview, the participants described how it was right and also commented that, other than the additional question regarding why they may not engage with science outreach programmes, they felt like they had been asked everything regarding their views of these experiences.

4.3.3 NEXT STEPS

Following the pre-pilot/pre-test and implementing the amendments, the interview schedule was piloted with a further participant who had engaged in the pilot in Stage 1 of the study (Section 4.1). The time of the pilot interview was 21 minutes which aligns with the time specified in the modified participation sheet. It was noted that on the interview prompt sheet one question had been duplicated, therefore this was removed and not asked a second time. Other than those outlined above, no further amendments were made following the pilot interview. Thus, the answers from this participant produced reliable data that links to the themes of the research questions and could be used in the main data collection of Stage 2.

4.4 STAGE 2: SEMI-STRUCTURED INTERVIEWS

Following the revisions of the interview schedule, participants for Stage 2 (*n*=8) were purposefully selected based upon their responses on the questionnaire, to continually engage with the research study. Those that had been agreed to be contacted grouped into 'primary', 'secondary' or 'FE' sectors ensuring there was representation from all educational phases. Participants who had agreed to further communication were selected randomly by assigning a number to each participant and using a random number generator to determine who should be contacted first. Three participants (*n*=3) were selected from the 'primary' phase, three participants (*n*=3) from the 'secondary' phase and two participants (*n*=2) from the FE phase were emailed with the relevant participant information sheet. If there was no response from the participant after one week, a reminder email was sent. If still there was no response after two weeks, a further participant from the relevant group was randomly selected and contacted by email. This ensured that although the sample was small, it was representative of the population of those who indicated they would like to continue engaging within the study. The interview was undertaken at the participant's own school to create a purposeful environment (Davies, 2007) and field notes were written shortly after each interview, as well audio recording the conversation. Upon return from the interview, the researcher recorded their own written account of each interview for future reference, and the audio recording was transcribed verbatim.

The TA of the interview transcripts were analysed using the NVivo software programme (QSR International Pty, 2017) and these were with the data for Stage 1. To continue to maintain the anonymity of the participants , each has been identified by a three-key code which starts with an 'I' to indicate 'interview' (research tool), a letter which corresponds to the educational level they teach at ('P' for primary, 'S' for secondary and 'F' for FE) and a number. The data was coded, and new themes emerged. These themes were then refined and defined (Table 4-5) and the results of which, are presented in the three following sections (Appendix P: NVivo stage 1 and 2 examples of working has an example of the process).

Table 4-5 Additional emergent themes from the TA of the interviews

Section No.	Theme	Description	Sub-themes
4.4.1	The pragmatics of the science outreach programme	Any reference to the design and the delivery of science outreach activities. Included are descriptions of both positive and negative barriers for engaging with these programmes.	• Logistics, design and delivery of the programmes. • Outreach involves external partners. • The perceived impact upon different groups of learners.
4.4.2	The positive impact upon motivation and learning in science	Any positive references about engaging with outreach programmes and the impact they have on the learner and teacher. This includes creating new experiences and the perceived benefit on learning outcomes in science.	• Perceived positive impact of science outreach programmes. • Science outreach supports learning in the classroom. • Hands-on access to unique resources and activities.
4.4.3	Placing science in real-life contexts and promoting careers within the field	Comments regarding how science outreach programmes further place science in a real-life context and how it may provide guidance on careers.	• Outreach provides a wider knowledge of careers in science. • Outreach exemplifies how science is applied in a real-life context.

4.4.1 The pragmatics of the science outreach programme

Teachers discussed how science outreach activities often involve external agencies visiting school or for schools to visit their workplace. This was referenced 73 times in either the questionnaire or the response from the interviews. Examples of the inbound activities included visits from ‘mad’ scientists; the Quantum Theatre Group; a scientific roadshow and science clubs ran by parents. Whereas, examples of outbound experiences included: residential visits to outbound centres; science festivals at local universities; visits to industries local to the UK for example, Tesco, Jaguar Land Rover; United Utilities and Pentagon Chemicals. The links with industries seem to be associated with career fairs visiting schools or being co-ordinated through a specified event. Participant IF1 described how, before funding cuts, the companies would get government funding to close some of the factories for a day so their students could visit; however, this no longer happened. The participants provided similar descriptive accounts of many of these specific experiences and discussed what the event involved and how many students attended. Whist participants recalled the outreach experiences they also illustrated how difficult these were to organise, quite often due to time, money and location constraints. The event location was an aspect which had not been highlighted in Stage 1 of the study, but potentially is a barrier for schools wanting to participate in outreach programmes:

> It's a bit hit and miss round here cause we live in the Lake District, so we're totally cut off…. we get the planetarium to come in once a year, and we do that but to be honest, its few and far between because we're so cut off…Even to get to Manchester is like two hours on a coach. So it's quite rare we get out, or people come to us because it's such a long journey…we went to see Brian Cox, and that was an hour and a half journey to go up there and see him. (Participant IS2)

Although this was just the experience of one of the participants, it could be representative of schools that are isolated in location. This is a barrier to accessing outreach activities, even if there is an abundance of enthusiasm to do so. Therefore, it is suggested by the researcher that outreach providers devising programmes could reduce this concern by using communicative technologies or mobile laboratories to ensure children in rural schools receive similar opportunities. Sewry et al. (2014) describe how science departments from an HEI in South Africa, have taken active steps to involve communities by inviting teachers to inbound CPD sessions utilising undergraduate students. The undergraduate university students obtain academic credit for their involvement with target communities that are disadvantaged in both urban and rural environments. Sewry et al. (2014, p.1615) surmise that "as the teacher at the rural village school so poignantly pointed out, community engagement also provides a conceptual bridge between what would, without the outreach activities, remain two separate worlds". It is recognised in both the interview responses within this doctoral study and wider literature, that location is an additional barrier to accessing science outreach programmes due to logistics and cost. However, it is agreed that when this barrier is reduced, then the benefits for learners attending these events can be immense. Thus, this pragmatic issue should be considered when designing science outreach programmes making the experiences more inclusive. The issues surrounding time and money are significantly increased when adding location, as a considered constraint too. Participant IS3 highlighted that these factors remain a significant barrier when engaging with science outreach programmes:

> Time… it's so difficult getting kids out of school now, erm, there's so much paperwork that needs to be done you know, erm, the risk assessments and there just seems to be so much more now, obviously with all the changes and above that it all links back to time, Particularly, I know if we didn't have 'Chemistry for All' who pay for everything

> and send the coach and all of that, the likelihood of us doing something like that would be minimal, you know erm, there isn't really funding for anything. (Participant IS3)

Participant IF2 reflects on what prevents them from further engaging with science outreach programmes "I think for me personally, its time. I don't really have time to form links with universities and organise events with them or organise having them come in". Participant IP1 adds that "It's the cost that stops you doing some of these things, even though you know that the outcomes are really good but budgets are really tight".

When considering outreach programmes, participants provided an account of who was delivering the outreach session, which ranged from qualified engineers, PhD students or other pupils delivering the activities to younger students. However, participants did indicate that the deliverers needed a certain skill set to ensure the experience was inclusive and successful. Participant IP2 recalled how these programmes should create 'wow' moments and gain the attention of the learners. Although the deliverer would "need to be flexible", and if aspects were not working, the activity would need to be adapted in-situ. This participant outlined how on particular trip, the class had been divided into two groups, and she had experienced a facilitator who had amended an activity for the learners, but the other group had not; so "we had a very different experience in my group to the teacher next door". Thus, this participant suggests how if the partnership is with a high school "they may not be used to teaching children who are so young because Y5 is a big step down from Y12". Participant IP3 added that as the facilitators are not teachers, they may not always be able to manage the behaviour of the learners, and therefore, the main teacher would need to facilitate this aspect. Five out of the eight participants interviewed discussed the background of the facilitator, and these references align with responses drawn from similar research. Goodman (2002) suggests that some scientists who deliver outreach programmes do not know how to relate to school students, but equally, teachers may feel uncomfortable having an 'expert' in the classroom. Tuah, Harrison and Shallcross (2009) reviewed responses from teachers who engaged with a chemistry outreach programme; in which a third of the participants highlighted that a talk regarding 'Toothpaste Chemistry", was too advanced for their students. Szteinbeg et al. (2014) suggest that a way to bridge the gap between teachers in schools and researchers at university is to further open the lines of communication to foster collaborative professional development. The relationship should be mutually beneficial, assisting with bridging the gap. These suggestions, along with discussions considering CPD for teachers, are key to the design of the researcher's proposed outreach model and are elaborated upon in Section 4.5

Another pragmatic issue surrounding the design and delivery of outreach work expands on the ideas regarding the impact of the outreach programme being dependent on the individual student (Section 4.2.1.2). During the interview process, Participant IF1 described the attitudes of a group of students who visited the Jodrell Bank observatory, Cheshire, England to learn about spectroscopy and how "they're happy to go because it's a day out of the class, …out of the 35 students we take, there's probably about 15 of them who will probably not be interested because biology is the bit they're interested in". Participants IP3 and IS1 discussed how learners may have unrealistic expectations of the day, or find the activities that are meant to be 'exciting' are not, for example, lighting a Bunsen burner and conducting flame tests. Thus, when designing an outreach programme in science, it is worth considering whether the activities are original, provide information regarding the activities and the target audience. This way, teachers can make informed decisions before attending events with their students.

Lastly, the participants considered drawbacks of these programmes; Participant IF1 suggested how the experiences could be further improved by "having some sort of lesson before the visit and something after the visit. So sometimes when we go to places, they will give us questions for students to take away". This notion is important and could assist with making stand-alone outreach events more beneficial as these 'one-off' events are not deemed to be the most impactful (Department for Business, Innovation and Skills (DBIS, 2014).

4.4.2 The positive impact upon motivation and learning in science

In general, participants were keen to discuss why they felt engaging with outreach programmes in science is beneficial for their students and themselves. The reasons outlined mirrored qualitative responses provided in the questionnaire (section 4.2.2); the interview allowed a deeper discussion. There was significantly enhanced detail regarding the identified sub-themes and how outreach activities can increase confidence, inspire students, assist with learning and be interactive. Participant IP2 discussed most of these during their interview highlighting the benefit of being involved in outreach activities was that it provided experiences for pupils that would not be available in regular lessons. Programmes of this nature allow different expertise to be shared with the students and teachers and involves specialist equipment that neither have used before. In addition, how these programmes are contextualised within the workplace is aspirational for students. For the pupils, the teacher described how the 'wow factor' that often accompanies many of these outreach initiatives, promotes the love of the subject for the teacher also. This latter discussion is important for many reasons as teachers are not only the gatekeepers to these experiences, but also the facilitators of transmitting science information and enthusing their students. Both teachers and outreach facilitators can be role models for their students in science. Rodd, Reiss and Mujtaba (2013) outlined that the identification with a key adult is an important element in an individual's participation in outreach activities. Therefore, activities that can provide an opportunity to further enthuse the teachers in science, and for the students to work with other adults, could be viewed as impactful.

Participant IS2 described how "I took some kids to the university last year, and they were making robots and it was all they talked about all the way home", amplifying the unique 'hands-on' practical activities facilitated at this event. Other participants highlighted how these unique activities were enjoyable for the students. Participant IS1 recalled how when Year 6 children came to visit (aged 11) they really enjoyed being able to use the glassware for practical science. Participant IF1 described how a colleague from the RSC delivered 'Spectroscopy in a Suitcase', allowing students to use equipment that was not available at the college; "the students loved it again, interacting with just people from outside". These activities are able to further promote the enjoyment of the subject which is a concept that links to the feelings of fun a student may have when they are engaged in science (Shumow, Schmidt and Zaleski, 2013). In their study, Grabau and Ma (2017) review the literature regarding enjoyment in science and found that there are several countries which reflect a positive correlation between science enjoyment and science attainment. In England, Braund (2009) concurs and concludes that enjoyment of a subject does have an effect on attainment, which could potentially influence future course uptake beyond compulsory school age. According to Jen *et al.*, (2013) and Hampden-Thompson & Bennett (2013) the factors which may affect enjoyment directly link to the positive relationship between a teacher and their students, and the type of science instruction; for example, lots of interactive 'hands-on' activities. This theme reviews many ideas regarding the benefits of engaging with science outreach programmes, which links to motivational theories outlined in section 2.1

In terms of science outreach activities being able to assist with learning in the curriculum, it was found that the participants in Stage 2 were able to provide specific examples. Participant IS3 outlined how after attending an event called 'Chemistry for All' with a Year 11 class (aged 16), the activities directly linked to the curriculum:

> When they came back after Christmas, they had a mock and basically everything that they'd done in Chemistry for All was on the mock. So it really allowed those students to have lots of revision and some hands-on experience with the content in a way really that they wasn't able to do in the lab [at school] (Participant IS3).

This particular event had been planned to complement the science curriculum and the support it offered the students was clearly outlined. Whilst some science outreach experiences are not directly related to the school science curriculum in England, or not discretely taught this could be trickier. However, Participant IF2 described an outreach event where "I think the chemical engineer definitely related it to the spec and whatnot". This was deemed as beneficial for the teacher and the students and highlights how activities can be adapted, but this does require a certain skill from the person(s) delivering the event, this links back to ideas outlined in section 4.4.1.

When it came to questioning the participants about their perceived impact of engaging with science outreach activities, there were variations in the responses from the different educational phases. Primary participants' ideas regarding the long-term impact were more tokenistic and wishful in meaning; for example;

> Researcher: So how do you think it positively affects pupils that attend?
>
> Participant IP1: They become more interested in science and more engaged in science. They say to me 'I can't wait to be in your class to do science', that kind of thing, just the excitement and the buzz that they get from it.
>
> Researcher: Yeah. And do you think the benefits are long lasting?
>
> Participant IP1: I'd like to think so [laughing].

There were similar responses from participants in the primary educational phase who 'hope' or 'thought' that these programmes would have a lasting impact. As you move to responses from participants from secondary schools, these were more focused and linked to how these experiences might have an impact on a learner's future career choices in science. For example:

> I think that it just allows, particularly for our students, you know, we're in quite a deprived area, it allows them to see things that they don't always see. They might not have a mum or dad or somebody who has gone to university, but they're actually able to go into university and be a student, really, for the day. I think it really does increase their aspirations and sort of opens another door for them really to think 'oh well hang on a minute, I could work really hard, and I could come and do this, I quite enjoy it'. You know, I think it really does raise the aspirations of our particular students. (Participant IS3)

This response highlighted how the impact could be dependent on different groups of learners, which aligns with inspiring students from a lower socioeconomic background; this will be discussed further in Chapter 5. The positives outlined by this experience align with the idea of changing perceptions of science, which can be impactful in the long-term. Eaude (2011) suggests that if pupils see a purpose and context in their learning, this will spark motivation and enjoyment to achieve. When questioning the participants from the colleges, their response to the questions were contrasting to their primary school peers, as they were able to provide specific examples of how attending an event -impacts upon on their student's' decisions about what to study at university or what career to pursue. For example:

> I know a lot of the students who I took to the engineering event have applied for engineering… as well I think the majority of our students who are doing A-Level programmes with us specifically, they all apply, at least, for university, so, you know, the outreach for them is insight that they wouldn't have if we're not doing it or if it's not happening. (Participant IF2).

It is evident here that students are able to use these experiences to find out more about their chosen career by speaking-to 'experts' in the field, who can assist them with the process. Participant IF1 describes how a trip to United Utilities (a water company in the NW of England) resulted in students applying for a particular university course and how outreach events:

> Actually, sets them [the students] in the direction they want to go and study at university because they come here with an idea of wanting to study science but they're not sure what science and as they go to these outreach things it helps them narrow down and discount things that people maybe thought they would have liked and go 'actually, it's not for me. (Participant IF1)

It is anticipated that the students who are studying science courses after secondary level (compulsory age of schooling in England), will have an interest in science and that is why they chose to study that field at college. -However, the responses from both participants do highlight that the experiences of science outreach activities at this educational level added value, as they assisted and supported learners' future decisions.

4.4.3 Placing science in real-life contexts and promoting careers within the field

This theme continues from discussions in Section 4.2.1.1 regarding how science outreach programmes can assist with placing science in an everyday context, providing information regarding science careers. It was highlighted from the questionnaires in Study 1, that participants felt that these activities were able to provide a unique experience which went beyond the 'ordinary' classroom. This is contextualised below:

> Oh I think the benefits are with the outreach, as I said before, giving the children the experiences, they wouldn't otherwise get in a normal science lesson. It's being in the workplace, it's having that huge range of equipment, and it's having the expertise the lecturers and the teachers they've got. We went to, the Daresbury Laboratory when we did our science project. We actually came back with a telescope which is brilliant. We worked with real scientists and we made jet rockets and they were set off with compressed air. We could not have done that in school, we just don't have the equipment and it's like those 'wow' factors the children will remember. When I was at school, we never had anything like this, we did pond dipping and that was it. (Participant IP2).

This response discusses the 'limits' within the science classroom and provides examples of how engagement in outreach programmes expands experiences for students, by using new spaces and people as resources. Additionally, these new settings may be of benefit as Lyons (2006) described how learners are not always enthused by the autocratic way science is presented in school. As well as these new experiences, the opportunity to engage with facilitators of these programmes, is highlighted by Participant IF2:

> They were speaking…people who work in industry and they had activities out as well, all individual activities. I mean all my students were, like, picking what engineer they wanted to be, they were telling me or that they couldn't decide whether, they said they always wanted to be a chemical engineer but now they want to be a civil engineer, literally just off the back of that event, you know.

This example highlights how one experience can have an impact on a student's future career decision, and how engaging with people who work in a scientific field is beneficial. Therefore, it is suggested that career advice not only reflects a specific event/talk but also can stem from the deliverer of a science outreach activity; including the environment the activity takes place in:

> When the students go into [a named university] … sometimes there'll be a student at the back of the lab, and I think even just being there opens their eyes to the opportunities that they could, you know, embark upon based upon a chemistry based further education. (Participant IS3)

Cleaves (2005) suggested that students in secondary schools disliked science as they found it boring and clear guidance of how the learning could link to careers, was not forthcoming. It is evident from the few examples discussed here, how science outreach programmes can be a platform to provide information to inspire students. By discussing careers and employment, learning in science is framed within a real-life context and not an abstract idea, allowing the students to question and relate to 'real-life' people. This revisits the previous idea that the facilitator of the programme and their own educational background can inspire and encourage learners. For example, Participant IP1 described how "The gardener we used last year, he did keep saying to children 'you'd be a great gardener or horticulturalist' cause that's what he technically was, so he did push that last year, it was good." The Participant continued to describe what several children in his primary school class said they wanted to be following their outreach experiences. Although, this is anecdotal evidence, it is important to ensure that careers in science are promoted at a younger age as according to the Royal Society (2004), 63% of the participants in their study (*n*=1100) had considered a career in science or engineering by the age of 14. This idea reinforces the findings from section 4.2.1 regarding the age at which outreach programmes should be delivered. It is to be concluded, in the context of science outreach programmes supporting careers advice, this should be at an earlier age and the examples from this study's participants highlight that it does and that children respond positively to this.

4.4.4 Stage 2 Summary

The purpose of conducting semi-structured interviews was to provide further information regarding teachers' perceptions of engaging with science outreach activities and to reflect upon these experiences. The addition of this data enabled sub-themes in Figure 4-3 to be refined into three themes: The pragmatics of the science outreach programme (blue); the positive impact on motivation and learning in science (purple); Placing science in a real-life context and promoting careers within the field (brown/orange).

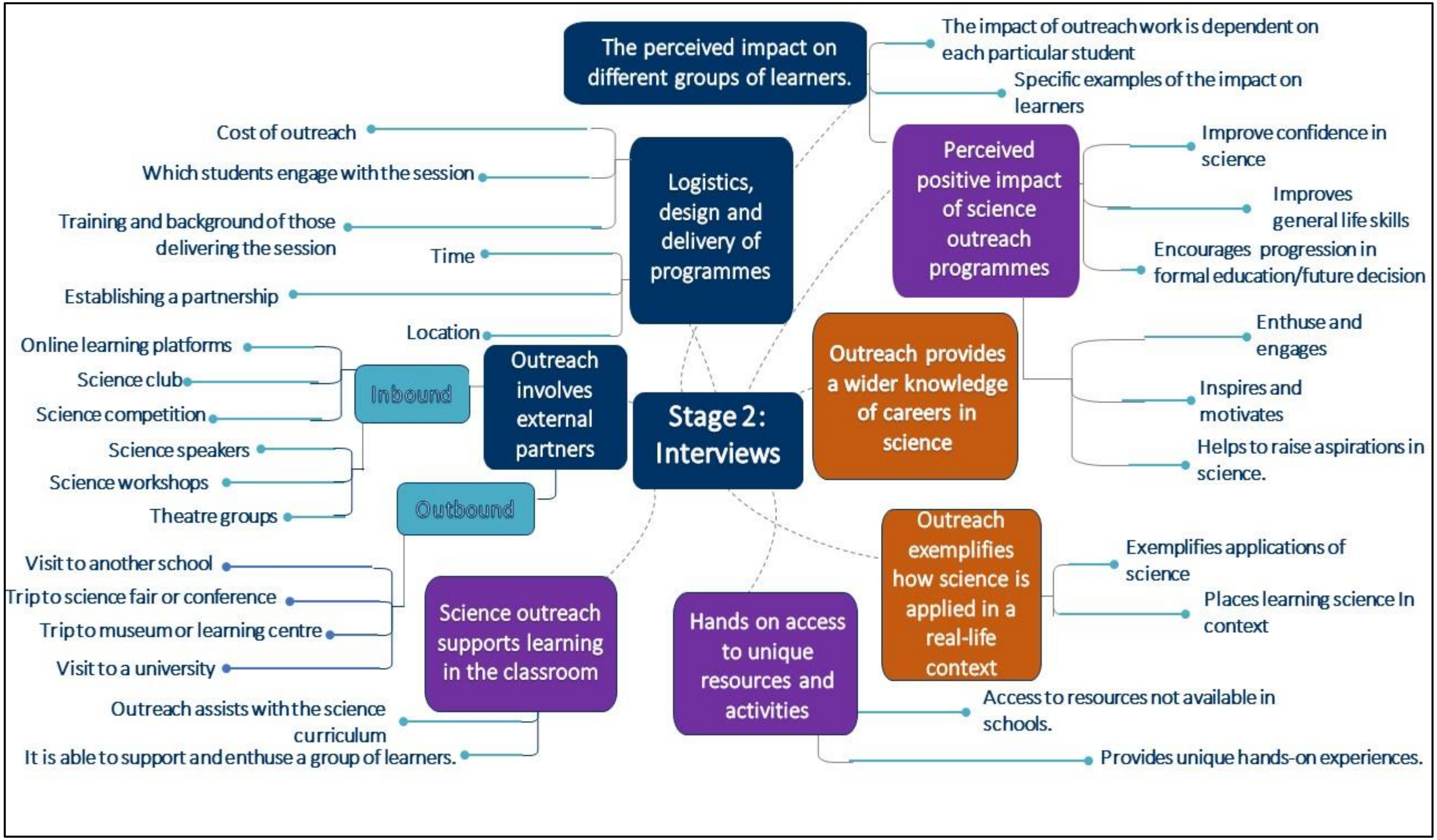


Figure 4-3 Summary of Stage 2 TA

These themes depict the benefits and drawbacks of these programmes, in terms of the design and delivery of the programmes. Muller et al. (2013) describe how interest can be invoked by ensuring that science learning has variety, engaging activities and a safe environment to ask questions. These outreach experiences do evoke positive reactions from the learner and mirror findings in the literature; this is captured by Participant IS2:

> For them, they're the kids who come away with, like, the more positive of 'oh wow, we could do that, I want that'. That would spur them on to at least explore the possibility of a career in science when they leave school and want to push on in their GCSEs. It just opens their eyes a little bit more doesn't it, to the different possibilities. I think, without all that outreach stuff, you don't see it now cos it's all just content-heavy, and it's quite dry. So now, it just gives them that flavour,–that inquisitiveness and makes them want to ask more questions rather than just being spoon-fed and more content.

This highlighted the benefits of outreach programmes and provided further evidence of the rationale for the engagement in these in science. However, the restrictions and drawbacks of these programmes were considered also. These points will also be crucial for the development of the proposed model to ensure that it is age-appropriate, fit for purpose and takes into consideration the previous experiences teachers have had when engaging with these activities.

4.5 PRESENTATION OF THE PHASE ONE MODEL.

The responses from participants from both Stage 1 and Stage 2 of Phase One of the research study, provide valuable information of the benefits of how science outreach activities engage learners. Therefore, this data was used to inform the key themes and design of the initial 'optimum model for science outreach programmes' and these were further underpinned and developed by a deeper, more focused literature review. The rationale for the context of the model is highlighted in the remainder of this chapter. The aim of this framework is to draw together primary and secondary data regarding outreach programmes in science, to propose a purposeful and impactful model for science outreach programmes. The proposed model is also intended to be a tool, which those who design these programmes, can use to ensure that the activities are age-appropriate and can support the learners, teachers and parents. The proposed model is presented in Figure 4-4. The presentation of this model is informed by the Waterfall approach, the principles of which have been used by Segue Technologies Inc (2019) to develop the shape of this optimum model for science outreach.

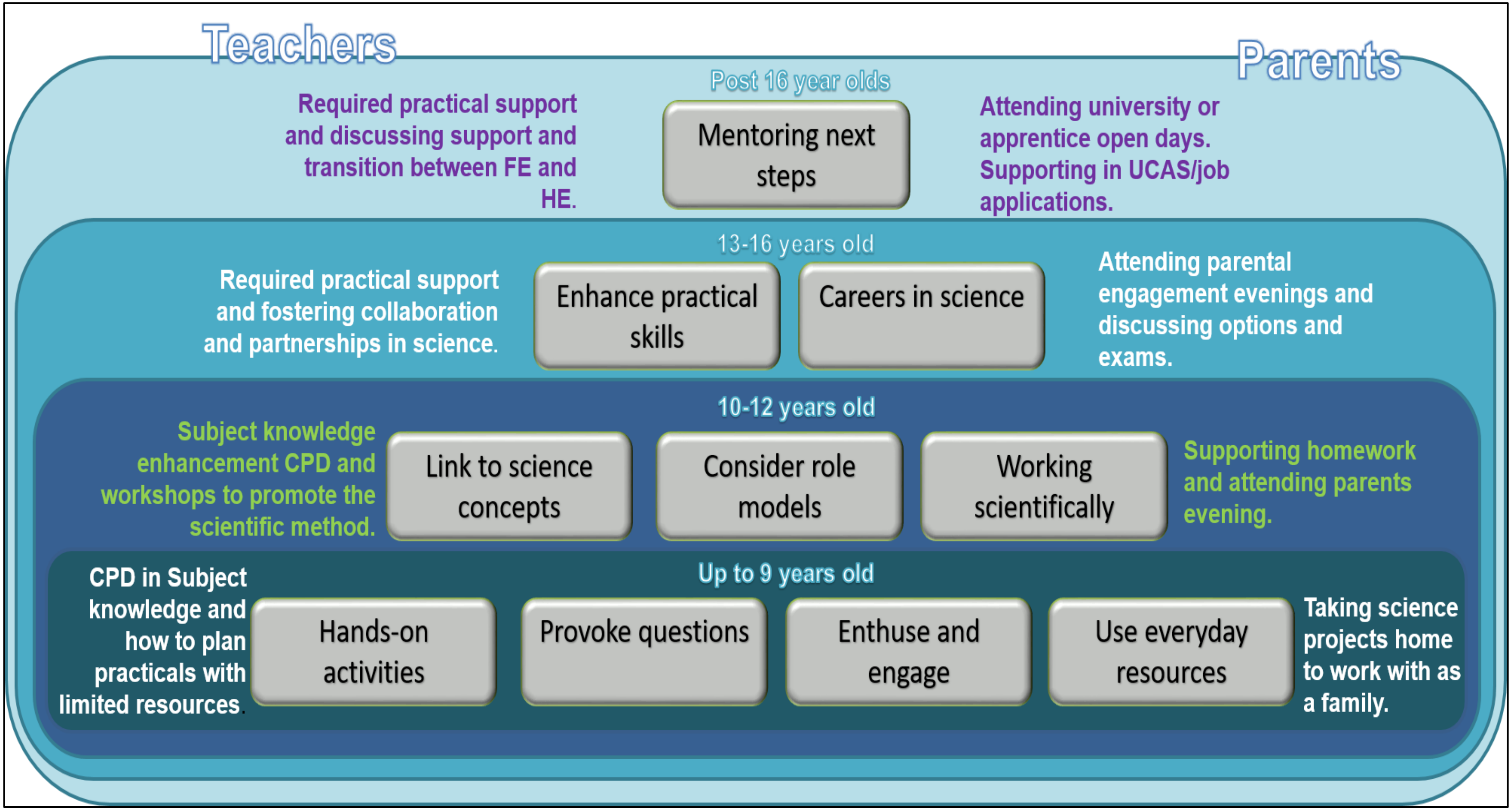


Figure 4-4 Draft 'Optimum Model of Science Outreach'

Segue Technologies Inc. (2019) outline that their approach is sequential in nature and is beneficial, as it outlines a clear process inclusive of 'stages' that operate independently. Each 'stage' of the proposed model builds upon the last 'stage' and includes the key categories from the previous one. Each 'stage' in this model is presented as different age categories, as opposed to specific educational levels, to ensure that the model could be used outside the English education system. For example, if a company in England wished to work with a Year 6 class, (learners aged 10 and 11), then they could focus on the key categories from that 'age label', but still include aspects from earlier categories; thus, planning sessions that are 'hands-on' and provoke questions. Therefore, it could be viewed that the 'first level' is the 'fundamental aspect' to all outreach programmes, the foundation to build upon. When working with learners in the highest age category, it is likely that they have already made choices regarding science (Oppermann et al., 2018); therefore, their experience with outreach programmes should still be engaging but should help to highlight and inspire those next steps into HE, or a career in the field. For reference, Table 4-6 provides information regarding how age corresponds to different educational levels in different countries. England has been included as this is where the sample of participants in this study derive from. USA, Canada and Australia are also considered as, according to literature, these countries are actively engaging in a wide range of outreach programmes. Table 4-6 aims to illustrate the differences in age ranges for the four main countries discussed.

Table 4-6 Age of child and their educational stage from an international snapshot

Age Range (years)	England (class name/school level)	USA	Canada	Australia
4-5	Reception/Primary	Junior Kindergarten	Junior Kindergarten	Kindergarten/Pre-school
5-6	Year 1/Primary	Kindergarten	Kindergarten	Prep or Kindergarten/Primary
6-7	Year 2/Primary	1st Grade/Elementary	1st Grade/Elementary	Grade or Year 1/Primary
7-8	Year 3/Primary	2nd Grade/Elementary	2nd Grade/Elementary	Grade or Year 2/Primary
8-9	Year 4/Primary	3rd Grade/Elementary	3rd Grade/Elementary	Grade or Year 3/Primary
9-10	Year 5/Primary	4th Grade/Elementary	4th Grade/Elementary	Grade or Year 4/Primary
10-11	Year 6/Primary	5th Grade/Elementary	5th Grade/Elementary	Grade or Year 5/Primary
11-12	Year 7/Secondary	6th Grade/Middle	6th Grade/Elementary	Grade or Year 6/Primary
12-13	Year 8/Secondary	7th Grade/Middle	7th Grade/Middle or Intermediate	Grade or Year 7/Secondary
13-14	Year 9/Secondary	8th Grade/Middle	8th Grade/ Middle or Intermediate	Grade or Year 8/Secondary
14-15	Year 10/Secondary	9th Grade/High	9th Grade/ Middle or Intermediate or junior high	Grade or Year 9/Secondary
15-16	Year 11/Secondary	10th Grade/High	10th Grade/High or secondary	Grade or Year 10/Secondary
16-17	Year 12/FE	11th Grade/High	11th Grade/ High or secondary	Grade or Year 11/College or senior secondary
17-18	Year 13/FE	12th Grade/High	12th High or secondary	Grade or Year 12/ College or senior secondary
18-19	FE resit-year			

The inclusion of parents and teachers in the model stem aligns with the developmental-contextual approach to lifespan career development (Vondracek et al., 1986); which was the pre-cursor to Schoon et al.'s (2007) developmental-contextual model of career development that underpins this doctoral study. Findings from Phase One of the study, recognise the importance of these two stakeholders, as they can support and shape children's destinations. Participants from both Stage 1 and Stage 2 of this research study, highlight how outreach programmes should be used to support a teacher's own scientific knowledge and involve parents. Thus, by including both teachers and parents, as part of the design of the 'optimum model for science outreach programmes', the model's impact in relation to children is enhanced; both in terms of the Development-Contextual Model of Career Development theory and to sustain standalone events. This is important as the Department for Business, Innovation and Skills (DBIS) (2014, p.95) highlight that "long-term, sustained outreach programmes are crucial to success in widening participation", including fostering partnerships at every level, which is encouraged in the proposed model.

Therefore, it is anticipated that those who design and develop outreach programmes in science should consider the stakeholders who are either the recipients of the activities or who can sustain the experience; thus, engage them using the suggested age-appropriate methods. The creation of the 'optimum science outreach model for lasting impact' presents several categories that are proposed to support the design of outreach programmes at each age-level. It is not intended that all of these categories need to be used in every programme, as it is a guide to how to conduct the activity, or what to include in the programme. These suggestions are described in detail below and include rationales from both the literature and this research study's participants from Phase One.

4.5.1 Up to 9 years old

This is the first age group of the model; it is quite a large age group and covers a significant amount of a child's experience of primary science. It was discussed that interests which develop at a younger age are often associated with play and response to stimuli and can be linked to future learning preferences (Leibham, Alexander and Johnson, 2013). Morias et al. (2019, p.303) state that "pre-school and primary school are the key moments that trigger the emergence of the desire to learn science". Therefore, the outreach activities within this age range, should enhance and further engage initial interactions and interests in science. Marsh, Craven and Debus, (1991) state that by the age of 8, a child has a multidimensional sense of self; this includes choosing what interests them. Therefore, outreach programmes at this age should help to promote positive feelings towards science to maintain the child's interest, developing into an individual with a much greater idea of self-concept.

4.5.1.1 Learners

Upon delivering science outreach activities to this age group, the focus for the learners should be centred upon; planning hands-on activities, to provoke questions from the learner, programmes that enthuse and engage the learner and should use everyday resources. These four identified categories are designed to foster a younger child's experience of science encountered so far, in a way that still incorporates the idea of exploratory play and aligns with Participant 35P's response that science outreach programmes are those which "motivates them to learn, and they enjoy the 'hands-on' experience." Desouza (2017) discusses how play is what is often most associated with early childhood education and the benefits of using play assist with the development of interactions with other children, how to self-regulate and generating a child's own ideas and viewpoints. The use of play aligns with constructivist theories of education. Fleer (2011) describes how play initiates children to consider rules and the use of objects; this encourages cognitive development. The *zone of proximal development* (ZPD), which is a central idea of Vygotsky (1978), is created as a result of this play within the school and fosters imagination. Piaget (1954) also valued the idea of play as a way for children to experience and practise their ideas before making them concrete. Sharp et al. (2017) agree as they describe how this exploratory approach to science can look unstructured, but children are experiencing something which they have not encountered before. Thus, exploratory play can be centred on scientific ideas (Morais et al., 2019). Therefore, this play should be mediated through the use of hands-on activities, which use familiar everyday objects. According to Harlen (2008), delivering science outreach programmes using these approaches will assist the child with their development and understanding of the world around them. Using these hands-on activities, was also described as an effective way to provide active learning experiences as many children often prefer these approaches (Morais et al., 2019).

The resources used for these activities should primarily be easily acquired. Although, many teachers reiterated the idea of Participant IP3 who described how "they [outreach providers] often bring resources in that we as a school wouldn't be able to afford to purchase or have stocks of"; thus it is important at this early level to use 'everyday' materials to promote teaching practical activities in the science classroom and also assist with children making sense of the world around them. Sharp et al. (2017) comment that it is often the felt that high-quality teaching is centred around high-quality resources; whilst this is true, it is the teaching approach that is the most important aspect, and the teacher having the confidence to utilise specialist equipment effectively. Participant 43P expressed this as they discussed how "science outreach should supplement the high-quality science teaching of the class teacher." Therefore, modelling outreach activities that assist with using more readily available resources will allow the activities to be more 'hands-on' and assist with future teaching ideas. Using these more accessible resources will also help to reduce costs of equipment which is useful to note since 41% of Participants (n=902) in a study by the Wellcome Trust (2017) suggested that primary schools did not have a suitable resource budget for science.

At this early stage, science should foster this natural curiosity and it should provoke questions regarding the world around us. McCrory and Worthington (2018, p.75) discuss examples of how young children can ask very complex questions at a young age. For example, they described how a teacher was asked 'what is a clone?' by a pupil after watching the film Star Wars. Whilst this is a more advanced scientific concept that can be controversial in nature, these types of questions arise from interactions in society to which children seek answers. According to McCrory and Worthington (2018), a crucial aspect of teaching is motivating and engaging students in these humanistic ideas which provoke questions regarding society to stimulate interest in them (Sadler, 2011). This is reflected in the aims of the National Curriculum in England regarding scientific enquiry, which describes how these enquires should "help to answer scientific questions about the world around them" (DfE, 2013, p.3). Whilst questions can provide or demonstrate engagement in science, the idea of engaging and enthusing pupils is important and included as its own category. Participant 38P states that science outreach "helps children to engage through stimulating activities that are usually difficult to deliver in a classroom setting". Therefore, the inclusion of questioning within the model aligns with the English National Curriculum and can assist with learning.

The impact of child being enthused and engaged by the subject can be life-long (McCrory and Worthington, 2018) and therefore, those who design and deliver these programmes need to to foster these positive reactions. There are strategies and tools for teachers to use to assist with engagement, motivation and skills development in science. Often an inquiry-based approach will promote active learning in science; this aligns itself to the constructivist ideals as it allows people to construct meaning from experiences (Jobrack, n.d.). A pedagogical approach to this is to use the 5E Instructional Model (Bybee et al., 2006) whose roots follow the ideas of Dewey (1922/1925) and Piaget (1936), which align with the philosophical approach of this research (Jobrack, n.d.). The first 'E' in this model is engagement; this stage requires the learner to access prior knowledge, and in doing so are able to develop a clearer understanding of the concepts giving the activity more meaning (Clement and Stephens, 2008). Desouza (2017) discusses how the engagement stage of this 5E model invokes interest, curiosity and captivates children. With any outreach programme, the facilitator (who may not have met the group of learners before) needs to access prior understanding and spark interest from the start of the activity. This will then enthuse the children to remain engaged throughout the activity so that the following step, whatever instructional model is being adopted, will be both purposeful and enjoyable.

4.5.1.2 Teachers

Teachers providing an active role, as part of these outreach activities, are considered within the design of the proposed model for science outreach programmes. Participant 20P states that "clubs or expert providers who come into schools to help develop science in class and with teachers"; demonstrating a collaborative and supportive partnership. These 'partnership' opportunities are beneficial for the learner but can simultaneously assist with the teaching of science. For example, Participant IP1 recalls:

> Cos I've done the science club, I've certainly developed my knowledge in terms of, like, chemistry and the vocabulary that I'm using cos a lot of the stuff that I get is from our local authority user. So, when I go to the science briefings, he obviously gives me a lot of ideas and the vocabulary to go with them which has been really good for my own development, yeah.

Other teachers provide further examples of how visitors in school, as part of these programmes, assist them. Participant IP3 states that they "like the people [visitors] that are coming in who are more specialist. I'm not a scientist really I have to say [laughing], it's not one of my strongest subjects." This also connects ideas regarding teachers' own confidence and perceptions of themselves, as science teachers. It is discussed how subject matter knowledge can have an impact on a teacher's own identify (Helms, 1998; Avraamidou, 2014). The idea of teacher identity reflects Bordieu's (1977) ideas of habitus and how this can influence teaching practices (Gokpinar and Reiss, 2016). The Wellcome Trust (2017) found that 68% of teachers (*n*=1010) 'agree' or strongly agree', they felt good at science, which illustrates a third of teachers felt otherwise. This means that these views could influence the science lessons UK teachers teach, and they may be more reluctant to teach the subject compared to others.

For example, Participant IP3, discussed how workload was a barrier for teaching science:

> If you're doing science in an afternoon, there's a lot of setting up to do, making sure equipment works. For instance, we're doing electricity at the minute, so I've had to spend an hour sorting all the electrical sockets out, making sure the batteries work, making sure the bulbs work, erm, and it is about time isn't it, I guess. It is frustrating when we haven't got the resources to do the experiments and things aren't there. It's down to cost and cost of resources and we have just spent quite a lot of money on science equipment and it's nothing when it's come, it's just a couple of little boxes. So, it is quite expensive.

This suggests that teachers struggle with using resources effectively in the primary science classroom and that additional training from specialists would be worthwhile. These responses from participants align with findings from a report conducted by the Wellcome Trust (2017). This report highlighted how 80% of schools (n=508) stated that improving teaching was in their science improvement plan; along with including a budget for science resources (53%) and specific CPD for science (37%). Whilst only 3% of these schools considered a 'partnership' between other schools and partners in this model (Wellcome Trust, 2017), science outreach programmes could assist with supporting these other areas that appear within the science improvement plan. For example, Avraamidou (2014) discussed how researchers have investigated how informal science learning experiences can support the development of teacher identity and science. These more relaxed experiences allowed the teachers to feel at ease, but simultaneously allowed them to demonstrate key areas that they recognised as part of the agenda of reforming science education, such as promoting positive values, facilitating hands-on activities and supporting inquiry (Katz et al., 2011). In addition, it was found that these experiences changed teachers' perceptions from focusing on grades to the impact on a student's own identity and science (Avraamidou, 2014). Thus, specific professional development can assist with subject knowledge in science and support pedagogical approaches to science teaching, especially with younger aged learners with appropriate resources.

4.5.1.3 Parents

Gokpinar and Reiss (2016) discuss how outside-school factors may influence learning in science, especially as the majority of a school-age child's time is spent away from school. This time can be spent constructing, reflecting and building on knowledge learnt in school with parents, family members and other role-models, and this can have an impact of perceptions in science. Participants did not comment specifically about the importance of parental support for these younger aged primary children. Therefore, literature is used to support the design of this category at this age as there is specific evidence for the other ages (see section 4.5.2.3, section 4.5.3.3 and section 4.5.4.3)

4.5.2 10-12 YEARS OLD

The next age range focuses on the move children encounter between primary and secondary education. In England, a transition in education occurs between each key stage, the most notable 'jump' is between Key Stage 2 and 3, where pupils move from primary to secondary school. Brewin and Stratham (2011 p,365) signify that this is "the most important time in a child's school career" as, this transition sees not only a change in expectations of learning for pupils, but also the learning environment and social-peer groups (Braund and Hames, 2005). Jack and Lin (2014) discuss how science interest often declines when students move into secondary school. This could be linked to findings of The Royal Society's Report (2012) regarding the transition in science as there is often a tendency to 'teach from scratch' at the beginning of secondary school. This approach is often used due to the inconsistent science experience learners at primary level receive. For example, Braund (2010) discovers that there is less practical work in Year 6 classrooms than often expected. This could relate to the withdrawal of Science from the Standard Assessment Tests (SATs) examinations at the end of Key Stage 2 (Ofsted, 2013) or link to Murphy, Ambusaidi and Beggs (2006) and Woodward and Woodward (1998) suggestions that primary level science is often not taught effectively, due to the lack of confidence of the teacher in the subject, .

Thus, whilst no participant indicated that transition was important, it was clear that participants in Phase One stage 1 felt that science outreach was more important for children in secondary than in primary school (see chapter 4.2.1.3). Therefore, the creation of this age range is not just to support pupils, but also teachers and their attitudes and awareness of this important time. This age range not only experiences a huge change in their own self, but biological changes as they undergo puberty (Brewin and Stratham, 2011). This stage of the proposed model has been included to not only support the scientific content of the curriculum but promote people and experiences to ensure that learners continue to feel positive about science throughout this transition.

4.5.2.1 Learners

Participants have previously recognised the 'power' of these programmes to raise aspiration in science; this is exemplified by the responses below:

> We have an issue with aspiration, and I guess children knowing what jobs they can do when they grow up. When we have visitors from different jobs come in, they were quite surprised weren't they that there are things that are out there that they could actually aspire to be. (Participant IP3)

> For them, they're the kids who come away with, like, the more positive of 'oh wow, we could do that, I want that' and it's, that would spur them on to at least explore the possibility of a career in science when they leave school. (Participant IP2)

As learners get older, scientific concepts become more advanced; however, at the upper primary level, the profile of science has been reduced (Serret et al. 2016). Additionally, career guidance is statutory only from Year 8 in England (12 years old plus) (DfE, 2018); therefore, looking at inspirational people in science can scaffold aspiration. Thus, having a science outreach programme that included role models, can have a significant impact on a child's perception of a particular subject (Cridge and Cridge, 2015; Maltese and Tai, 2010).

The Wellcome Trust (2014) found that there was a gap between quality instruction of primary science, that is dependent on whether individual schools, value the subject or not. When learners' transition to secondary school at 11 years old, they have a range of science experiences and therefore exhibit a range of emotions linked to the subject. Thus, this stage of the proposed model considers how outreach programmes can support and enhance the formal science learning, both within the concepts covered, and the working scientifically framework. The outreach design should also inspire children by meeting people who have contributed to the scientific world. Learning what people have contributed to science in the past and having the opportunity to meet people who are working in science now, can play a significant part in children's future decisions regarding science. Rodd et al. (2013) discussed how undergraduate physics students often recalled how they identified with a key adult at a younger age. Therefore, the inclusion of role models within this age group is able to support the ideas presented from both the participants and the literature.

In science education, the use of practical activities as a key pedagogy, is embodied within a plethora of literature (Darlington, 2015; Reiss, 2015; Needham, 2014; Williams, 2011; Abrahams, 2011; Abrahams and Millar, 2008). Thus, when designing and delivering outreach activities in science, these experiences can both support and enhance the process. Participant

35P concludes that "Some children would not have the opportunity to take part in practical work if the outreach work was not available".

Morais et al. (2019) discuss the progression of scientific concepts and how younger children can categorise these; however, children are unable to process mental models. It was also described is how as a child gets older, it is not possible for them to learn the required scientific ideas by just experiencing everyday situations; this coincides with the much more formal approach and laboratory-based setting of many secondary science classrooms (Morais et al. 2019). If, as a result of these programmes, the activities help to conceptualise learning because of new approaches of facilitators, then the learner's concept of their self and science becomes more positive, which could influence their future study. Therefore, the science outreach programmes can support these changes and whilst being different from the 'ordinary' lesson described previously by many participants (see chapter 4.2.2), it should aim to support these scientific concepts.

4.5.2.2 Teachers

In a consensus conducted by GOV.UK (2019), it was found that the majority of secondary school teachers did hold a relevant A-level in their science specialism (Biology 93.0%, Chemistry 81.6% and Physics 75.3%); though this was approximately 15% less for each teacher holding a relevant degree within the subject. Whilst initially this seems positive, teachers at KS3 level (age 11-14) and upper KS2 (age 10-11) usually teach the three sciences within this age category. In addition, the NFER (2018) found that science teachers (along with those who teach MFL) are most likely to leave the profession or move schools: This could cause a lack of continuity for the students in terms of their instruction which could exacerbate issues linked with transition (section 4.5.2). The recruitment of trainee science teachers is also below UK Government targets, which could have a later impact on the quality of instruction (NFER, 2018). Therefore, even for the next age group of the proposed model, science outreach programmes should support teachers by continuing to support their subject knowledge. Participant 37P described how for them "We have had a number of organisations visit our school over the past 10 years. All experiences have excited our children and supported teaching and learning." This amplifies the value of science outreach programmes, not only to support the learners but the teachers too.

In addition to this, even for teachers who are confident in their subject knowledge, Participant 7S adds:

> Science teachers that have been in post for many years might not have the knowledge of recent developments that could enhance the teaching and motivation of the pupils. When children see real life science in action and different presentations that can't be done in school it inspires and makes them go 'wow'!

The response from this participant aligns with Liversidge's (2009, p.162) discussion regarding "initiative and innovative 'fatigue' occurring in science departments" and how teachers could do with further support in developing and maintaining their creativity. Therefore, the model supports teacher CPD at this stage to assist with developing practices in their classroom, particularly those associated with the scientific method. Lamanauskas and Augienè (2018) discuss this idea of a 'natural' approach to science education which stems from the application of the scientific method by observing, predicting and analysing results from a young age. However, it is viewed to be problematic as Hodson (1998) discusses how teachers quite often provide so much of the conceptual framework for these activities, that there is little room to allow students to construct personal meaning and deeper understanding of the science.

Therefore, there should be some support surrounding the best way to plan these practical activities in science to make them more meaningful and promote scientific inquiry. Senlar (2016) discusses that to do so effectively, teachers should plan activities that allow students to think and act like scientists, starting with a discussion about how scientists work and how their knowledge is constructed. As teachers themselves may not be clear on this, it would be useful to share this as part of the design of science outreach programmes. Participant IS1 described how, during a science outreach event that was delivered in their school for Year 6 learners, the session focused on practical activities and undertaking investigations. The learners responded well to this unique opportunity as it allowed both the children and teachers to "get deeper and they could have chance to investigate, they could work in groups, they could get mucky, clean up, write it up, feel like they'd achieved". Thus, it can be concluded from both the literature and the data that outreach provided an opportunity to support this type of training and participants who have attended these events agree.

4.5.2.3 Parents

Chapter 2 explored the idea of motivational theories in science and the influence of parents/home on decision making in science. Within the developmental-conceptual model for career development (the theoretical underpinning of this research), career decisions are informed by both the parental SES and parental expectations. Thus, for this age category, the parental involvement aims to provide guidance on how to support homework and have the outreach provider attending formal events such as parent evenings, to increase parental engagement (Rodriguez and Elbaum, 2014; Watt, 2016). Equally, schools rely on parental support for their endeavours as a participant stipulates:

> What we do with our pupil premium money in some cases is we give them to parents in the form of, like, vouchers so they would go towards paying for trips and a lot of schools do that these days. Erm, but we rely heavily on parents, yeah, otherwise they wouldn't happen. (Participant IP2)

Whilst this example is quite specific, it highlights that as much as parents need schools, the schools need parents. Thus, there is a dynamic equilibrium between schools and parents, which is mutually dependent. Güven and Akçay (2019) describe how homework is a common institution across most educational levels and aims to engage students to develop their skills independently and improve their achievement, whilst also informing parents about student learning. The impact and amount of homework is something which has been studied with varying results, and there is yet to be an agreement on the optimum level. It was concluded by Güven and Akçay (2019) that homework did improve attainment in mathematics at an older age compared to a younger student. However, regardless of whether it does or does not improve attainment, it does create a platform for students to continue their learning at home and thus an opportunity for parents to support these practices. Using science outreach as a tool to help parents support science homework is also important when considering their SES. This indicator is often reflective of income. If income is low, there is a common assumption that the likelihood of a parent working in a STEM career or going to university is low (Gorard and See, 2009; Fleer and Rillero, 2008). This could mean that parents feel less confident supporting science at home, especially as concepts become more abstract, and thus scientific conversations are limited. Providing support as part of outreach programmes will allow parents to feel more equipped for this out of class learning, which could have further benefits for home-school relationships also (Section 4.5.1.3).

Participant IS1 described an attempt to have some extra science master classes to assist with the transition process between primary and secondary school, but that parental engagement was limited and problematic as "we can only access the few whose parents engage and bring them after school". Quite often, it is only parent's evenings in England where there is an expected chance for home and school to liaise as described by Inglis (2014) these are opportunities to facilitate conversations between teachers and parents. Similarly, to the example discussed by Participant IS1, Watt (2016, p.3) considers how different schools can foster different levels of engagement and there needs to be more opportunities to reach out to these "hard to reach" parents. Therefore, having a section of this model that focuses on including parents could provide many benefits in terms of supporting the parents themselves and the home-school relationships. In turn, this aspect of the 'optimum science outreach model for lasting impact' could improve school-outreach providers' relationships as this category could make engagement with the programmes more appealing to the schools also.

4.5.3 13-16 YEARS OLD

This group of learners are those who will be moving from KS3 to KS4 in the English curriculum. KS4 is where learners prepare to take their final secondary level examinations, in England, Wales and Northern Ireland. These are the GCSE examinations, but many other countries have an end of compulsory education examination (Barrance and Elwood, 2018). In most recent years, these examinations have been reformed in England, which has led to the removal of modular and coursework approaches in favour of terminal examinations. Winter (2017) describes how participants within their study believed the examinations resemble A-level style questions and approaches to the knowledge required. It is also outlined how GCSE grade boundaries are frequently adjusted. Therefore, teachers often find that significant examination pressures and curriculum restraints, can limit their engagement with outreach activities in science. This is illustrated by Participant IS2:

> The only issue we stumble against in school and it's not really a negative to do with the science, but we come up with, because all the GCSEs are so intense now, staff are really, really reluctant, to let them go out for a day and just focus on science because obviously normally they'd have two hours of English that day and an hour of maths, so it does impact, like, it impacts on other areas of school.

The stress for learners within this age range, who are studying for these examinations, can also have a negative impact on their attitudes towards school and science. Cleave's (2005) study found that many of the 69 participants aged between 13 and 16 studied, did not enjoy science at secondary school, even if they did plan to continue it. Participant IS2 supported these ideas as they discussed how "the curriculum is quite dry" and how by following this formal programme of study there isn't "a great range of dead exciting practicals we can do". This could be accounted for due to the prescriptive nature of preparing for the written examinations. Hence, science outreach programmes at this age should focus on supporting teachers and students in their formal science education to increase enjoyment, which may help to further inspire learners to think about science beyond school age. This link between enjoyment and motivation has been previously outlined in section 2.1.

4.5.3.1 Learners

In GCSE Science, students are required to participate in 'required practical activities' constraining schools' delivery of the curriculum. Participant IS3 outlined how "We haven't got much money, obviously, to do these things, we need to buy textbooks and all of the, you know, the actual chemical". Therefore, having outreach activities which can support this aspect of the GCSE specification gives the activities a purpose and students see more 'value' in the activity as it scaffolds their understanding for their examinations in science. In terms of enhancing the practical activities in schools, Participant 51S found that "science outreach allows students to undertake practicals in a way that they would not be able to in a school setting". This reflects several comments from other participants (for example, participant 42P's comment in section 4.2.2.1) who elude that these programmes provide experiences that can go beyond the learning provided in school. Outreach programmes provide access to new equipment that is not at school, which the teachers value too. This is supported by Participant 14S who described how these activities are opportunities for learners to experience new styles of teaching and practical science that school cannot provide. It is hoped creating this variety in instruction will help to maintain engagement for a learner as they move through the school years. Bedford's (2017) study used a mixed-method approach to question Year 10 (14–15-year-old) students regarding what motivates them in science. It was found that the important factors linked to self-regulation, self-efficacy and task value. These ideas all support motivational theories as discussed in Chapter 2.3.1. Bedford (2017, p.426) summarises a task value as "the personal value attached to a particular activity or skills". In terms of the generation of the proposed model in this study, 'task value' is included in the categories 'enhancing practical skills' and 'careers in science' within the model (see Figure 4-4).

Participant IS1 discussed how many of their outreach events involved a focus on careers; for example, it was described how an event focused on roles “from doctors down to care home assistants so there is a range of careers that are possible from it”. Therefore, it can be demonstrated how these events become more focused on a particular potential career which follows on from ‘role models in science’ in the 10-12 age range. This reflects the motivation in science research from Bedford (2017), as if the outreach task identifies careers that are of interest to the students, then the students find value in the activities. For example, Participant IS2 recalls a visit to a university where professors provided information regarding careers and how this linked to educational qualifications; this participant described how this was a very inspirational event for their students. Reiss and Mujtaba (2017) describe how careers education is not taught well in schools in the UK; therefore, including it as part of the proposed model for science outreach design and delivery will further support this.

4.5.3.2 Teachers

When Participant IS3 explains what could make you want to engage more with science outreach programmes it was stated that that “the demand on practicals is obviously much greater with these specifications and everything”. Therefore, cost and confidence in these practical resources could be further supported during these outreach activities. In England, this is of particular interest with the current GCSE science specifications for teachers that are working with students aged 13-16, as there is an increased emphasis upon required practicals, which are now examined (Ofqual, 2015). Wilson et al. (2016) discusses how this has been one of the most significant changes to the GCSE science qualifications providing the opportunity to re-evaluate the effectiveness of practical work in science. Similarly to ideas presented in section 4.5.2.2., Yeşiloğlu and Köseoğlu (2020) discuss how often these science ‘practicals’ do not match the epistemology of science and leave students feeling confused regarding the role of experimentation in scientific discoveries. Therefore, opportunities to support teachers in their instruction of this practical pedagogy can support authentic and effective teaching and learning.

There are a variety of continued professional development (CPD) programmes, which aim to improve teachers’ ideas and practice in science practical work. However, Abrahams et al (2014, p.271) continues to recall how science teachers found CPD useful, but “they [the CPD facilitators] seemed to be expecting miracles”. Thus, learning from this research and the findings from Phase One of this doctoral research study; indicates CPD offered as part of outreach programmes needs to support teachers in reaffirming the nature of practical work in science, the focus of which could be the required practical experiments. The likelihood of science outreach programmes being able to offer this sustained support to schools is low due to funding and timescales of projects. However, if outreach programmes helped foster collaboration between schools, these networks could be self-sustained over a longer period of time, thus increasing the impact.

Participant IS2 described their engagement with a science event:

> [It] involves lots of networking with other schools and working collaboratively with other schools. We have got, we've got clusters here in [named location], and I know that I've got links with two or three schools in [named location] and they're subject leaders. So, it's sharing expertise really, sharing ideas, like that Facebook page.

This indicates how science networks can be beneficial for many and as science outreach programmes often work with several schools, this could facilitate these discussions. Bristol ChemLabs chemistry outreach programme, that was evaluated in Section 2.7, and Glover et al. (2016, p.92) described how teachers are keen to discuss the benefits of 'partnership' and 'links' that arose from outreach activities. Therefore, based on data collected in this research study and literature, there is a clear rationale for supporting teachers' CPD and fostering partnerships between different establishments in the proposed model for science outreach programmes.

4.5.3.3 Parents

Following on from participants' ideas in section 4.5.2.3, continuing to further foster parental engagement opportunities for this age group of children is still important. It could be that the focus is to ensure parents are more aware of the formal examination procedures that their children will experience and how to support this process at home. Watts (2016) finds that if parental engagement is high, even when the SES of the family is high, it is the fact that the parents have a positive view of education and have material resources that can assist their child at school that become the most significant factor. If parents engaged with the deliverers within outreach events, then parents could review their own beliefs about science, which could impact on a child's own conceptual development (Gutman and Schoon, 2012). With regards to specifically using science outreach events to do so, McClain and Zimmerman (2014) find that when parents were asked to recall a prior science experience, many were linked to out-of-class learning. This further indicates that outreach events can be powerful. The data collected for this research study, indicated how teachers value outreach activities to engage parents:

> I think it would be really beneficial if we could keep them through into the evening and have it tied in with open evening so we could get parents to then engage with them so they could come and talk to subjects and then go and talk to the universities and they could then see that whole picture for their child and start seeing that it's achievable instead of it being something that the child goes home and says 'this happened in school today', that the parents were then part of it as well. (Participant IS1)

> Everyone's parents were invited to go because the closest uni to us is an hour and a half away as well, so a lot of the time the kids don't even think of taking science up. We do a lot of stuff with getting parents in and getting them to think a bit further than getting an apprenticeship in the yard. (Participant IS2)

Therefore, the derived model aims to support making parental engagement common practice when considering the design of science outreach programmes.

4.5.4 Post-16 year olds

When students leave secondary school, they have a lot more freedom in what they chose to study. Therefore, students who have chosen to study STEM subjects at Level 3 will have self-selected this, and it can be anticipated that they either enjoy the subject or wish to pursue a career within the field. Taylor's (2015) study applied the theory of planned behaviour, to explore what encouraged students' subject choice at A-level. It was found that parents, along with perceptions about the positive outcomes from the students, were the two most important factors. Therefore, this 'level' of the proposed model focuses upon learners who are aged 16 and above and are studying science-related subjects beyond compulsory school age. Thus, in addition to the previous components of the model, it should support, promote and encourage students to maintain their interest in science; whether they chose to go to university or move into employment afterwards.

4.5.4.1 Learners

When considering science beyond the compulsory school age, Shirazi (2017) discusses how many students feel indifferent towards science and many do not aspire to work in science. There are a number of reasons why a child may feel like this, including money and family pressures, the science course studied and their previous science teachers (Shirazi, 2017). It is not a given that once enrolled onto a science course, the student will complete it. Christodoulou (2017) stresses how learners find that there is a noticeable transition between GCSE and A level courses; resulting in their resilience and motivation needing to be monitored closely, to ensure they persevere with their science studies. In addition, learners who are post-16, will be considering their next steps; HE or the world of work. Hence, it is pivotal that science outreach programmes are designed to inspire, encourage and nurture their choices. Participant IF2 explains how their students were interested in meeting different types of engineers; the participant described how the engineers were "talking to students and talking about [the engineer's] job, and how [the engineer] got into it…and how it relates to, you know, their studies". This event that Participant IF2 alluded to allowed students to ask the 'experts' questions, as they could provide informed guidance for the students. Even students who do not want to study science beyond Post-16 level can gain from these programmes. Participant IF1 recalled how:

> It [science outreach events] builds their confidence in terms of if they were going to have an interview. They may be a bit more confident about talking to strangers because in FE that is the biggest thing, the confidence. Picking up a phone, talking to a stranger is such a big barrier for them.

Therefore, whilst the mentoring process at this level of the proposed model, may result in students deciding they do not wish to continue in science, there are still many skills that can be developed during outreach programmes. The design of the programmes at this stage should still encompass aspects of prior age ranges, to ensure that they are purposeful and engaging. However, focusing on how to support and encourage the 'next steps' can have a direct impact upon an individual's choice. This supports previous ideas regarding the continuation of choices in science and who may influence these (Section 2.1).

4.5.4.2 Teachers

Likewise to the discussion in section 4.5.3.2, participant IF2 suggested that having science outreach programmes that were "more closely linked to the exam board specifications" would improve their engagement levels with these types of programmes. Therefore, much of the rationale to support teachers at this age level in the proposed model continues from the discussions outlined in Section 4.5.3.2, as A level courses in science examine the 'required practicals' element too (Wilson, Wade and Evans, 2016). The focus on the reforms for the science suite of A-level examinations ensures that 15% of the examination will link to the practical skills students have encountered, and unlike the GCSE model, they will be given a pass/fail mark for their assessed practical portfolio (a record of these required activities). Coward and Cray (2014) describe how changes at A-level were made to support transitions into HE, as many Level 4 undergraduate students had insufficient practical skills at the start of their course. This therefore also supports the need for outreach programmes to further support the transitions between FE and HE, as it can assist with developing core skills and allowing students (and teachers) to see the differences between learning environments and expectations. Participant IF2 describes how an outreach event in a physics department at a university was able to highlight misconceptions and a wider ranges of courses and similarly, an engineering day allowed learners to understand different 'branches' of this STEM subject that they had not heard much about. These partnerships can be beneficial, as Shaw et al. (2010) found that two of the teachers in their study perceived that the chemistry outreach programme had encouraged their A-level students to apply to the university that had offered the outreach activity.

The support for teachers within the proposed model of science outreach presents a similar rationale that was outlined earlier. Literature links personalised choices to teacher influence (Maltase and Tai, 2010; Hattie, 2012; Urdan and Schoenfelder, 2006). Shorazi (2017) explains how learners always expect practical activities in science regardless of government reforms (DfE, 2014). Participant IF1 recalls an experience of engaging with science outreach programmes and how "we've been to the PCR day, and the students get to go in and use PCR and DNA extraction and electrophoresis; we've got some of that kit here, but we can't do PCR, it's too complicated". This example illustrates how the design of science outreach programmes supports formal learning in the classroom and allows the teachers to continue to provide the expected instruction to support exam specifications.

4.5.4.3 Parents

At Post-16, parents who have a child studying a science subject at this non-compulsory age will know their child has an enhanced interest in science. Participant IS1 recalls how many sixth form students' parents/family in their school are "second, third-generation unemployed" but how engaging with outreach opportunities "makes them [the student] realise they can go to university and there's life outside of where they live… it raises that level of aspiration". Whilst this is a positive, for some parents, this may be a new experience especially if their own educational background was limited. Therefore, having science outreach programmes designed to support parents and their child is beneficial for all. The continued engagement of parents at this level could also be deemed more crucial, as students will often seek part-time employment, especially if from a lower SES; thus, parents need to encourage students to be able to maintain a balance between their studies and work (Gorard and See, 2008). Thus, at this educational level there is also issues regarding expenses of the programmes. For example, participant IF1 discusses how parental financial support is still required at FE level and quite often because the "college won't fund it, and the students won't pay for it unless you ask them at the start of the year which we didn't do". Therefore, using science outreach to continue the positive relations between home and school/college can help to alleviate some of these financial stresses.

4.6 Chapter Summary and Considerations for Phase Two

The development of the proposed optimum model for science outreach programmes has been embedded in findings from the data collection of Phase One, Stages 1 and 2 and supported and developed by the inclusion of wider literature. With regards to learners, who are central to the proposed model, how they benefit is by further engaging and enthusing them with science. The approaches are aligned with age-appropriate activities that link to the formal National Curriculum in England and are therefore able to support teachers (DFE, 2013). This curriculum was chosen as it matches the experiences of the participants in the study; however, much of the wider literature is from across the globe, so there is the potential to use this model internationally. The devised model includes how science outreach programmes can support both parents and teachers. The initial rationale for this came from the developmental-conceptual model for career development, as this theoretical lens has informed the research design; however, participants within this research study exemplified parents and teachers as stakeholders. In the literature, it was found that "teacher personality and teaching style are one of the top three factors" (Shirazi, 2017, p.1901) that can affect school experiences. Therefore, further supporting CPD of teachers can assist with specific pedagogical approaches in science to improve science instruction and the experience for the learner in formal science lessons. In terms of parents "For many schools, parental engagement seems to be the worst problem and the best solution" (Harris and Goodall 2008, p. 286). This presents challenges and outlines a consideration for Phase Two of this doctoral study. The devised model has outlined why the inclusion of parents is important but using focus groups of teachers, allows them to provide examples of how they have engaged with parents previously.

In addition, the proposed model provides a 'starting point' for participants to focus upon how outreach programmes may assist pupils from lower SES (using pupil premium as an indicator- Section 2.2.1). This links directly to Research Question 2: 'What do teachers in the North-West of England think about science-based outreach programmes, especially in the context of children's social demography?' It also helps to further understand the additional two research questions by providing further perspectives about how outreach could influence an individual and what improvements could be made to science outreach programmes based on teacher's reflections of these.

Phase Two of this doctoral study, will deduce the readability of the model and whether the current proposed model meets the needs of the teachers, based upon their prior experiences of engaging with outreach programmes in science. This process will allow the proposed model to be refined to inform the researcher in the presentation of the overall final model. The nature of data collection in Phase Two will add to the rich discussions regarding teachers' perceptions of science outreach activities. Thus, providing further insight into the practice of using these interventions in schools and how they might be improved upon in the future.

CHAPTER 5:
PHASE TWO

The aim of this chapter was to outline how the draft model has been refined from the draft framework presented in the previous chapter and to solidify teachers' views of their engagement with science outreach programmes. During Phase Two, there were more specific questions that asked participants to focus on specific groups of children within their classroom and how these interventions may best impact on them. The group were asked specific questions about the impact science outreach activities may have on learners from a lower socioeconomic background, which in the sample is identified as those in receipt of a 'pupil premium'. This enabled the generation of further data and modified the model to show how science outreach programmes may be more impactful for this demographic. The aims and structure of this chapter is summarised in Table 5-1 all the data has been derived from focus groups of teachers from primary (*n*=2) and secondary (*n*=2) schools within the North-West of England.

Table 5-1 A summary of the aims and structure of Phase Two

Aims of this phase	How the data will be analysed	Presenting the data	Location
Explore teachers' perceptions of their engagement with science outreach programmes.	Adopting principles of modified constructivist grounded theory (mGT) (Charmaz, 2006)	A presentation of the emergent theory	Section 5.2
Consider what the most important aspects of this model when working with learners in receipt of pupil premium.			
Refine the draft model presented in chapter 4.	Combining data from the mGT proess, direct comments within the transcripts and annotated diagrams presented in the focus groups at the time.	Visual Presentation of a model	Chapter 6
Present a model that focus on key areas when designing and delivering science outreach programmes that target learners from a low SES.			Chapter 6

5.1 ANALYSING THE DATA

This phase drew upon principles of modified constructivist GT, as it was explained in Chapter 3 how time constraints of the research project meant that this approach could leave itself vulnerable to criticisms regarding the rigour of this scaled down process (Soliman and Kan, 2004). Urquhart (2013) discusses how GT follows the notion of other qualitative methods as it does find descriptions provide context for the data; however, GT extends this presentation of data by using more systematic processes through theory generation. As described in section 3.6.1, the constructivist aspect of the GT method acknowledges the researcher and their multiple standpoints and allows the researcher to take a reflective stance (Charmaz, 2017a). Charmaz (2017b) also outlines how constructivist GT follows a pragmatic heritage which makes the approach a little more flexible than the original presentation of GT by (Glaser and Strauss, 1967). This approach aligns with the paradigms of this PhD (see section 3.1) and develops the process for example by allowing the memos to be used to compare data with data and include raw data (Urquhart, 2013).

The data that was collected using focus groups (*n*=4). These were recorded using audio equipment and transcribed verbatim. It was decided that it was not important which participant was contributing to the discussion as their perceptions were seen as a collective voice (see Appendix K: Focus Group Schedule). Following each focus group a vignette (see Appendix M: Vignettes from each focus group) was created to provide context for each school and capture any of the researcher's thoughts during the process (Braun and Clarke, 2013). There may be some descriptive analysis intertwined with the accounts but Urquhart (2013) explains that this often the case when writing-up qualitative findings. Memos were also used to assist with capturing some of the important themes from the focus groups themselves and the groups' voice is collected holistically (Cohen et al, 2018). A summary of this process for this phase is captured in Figure 5-1 on the next page.

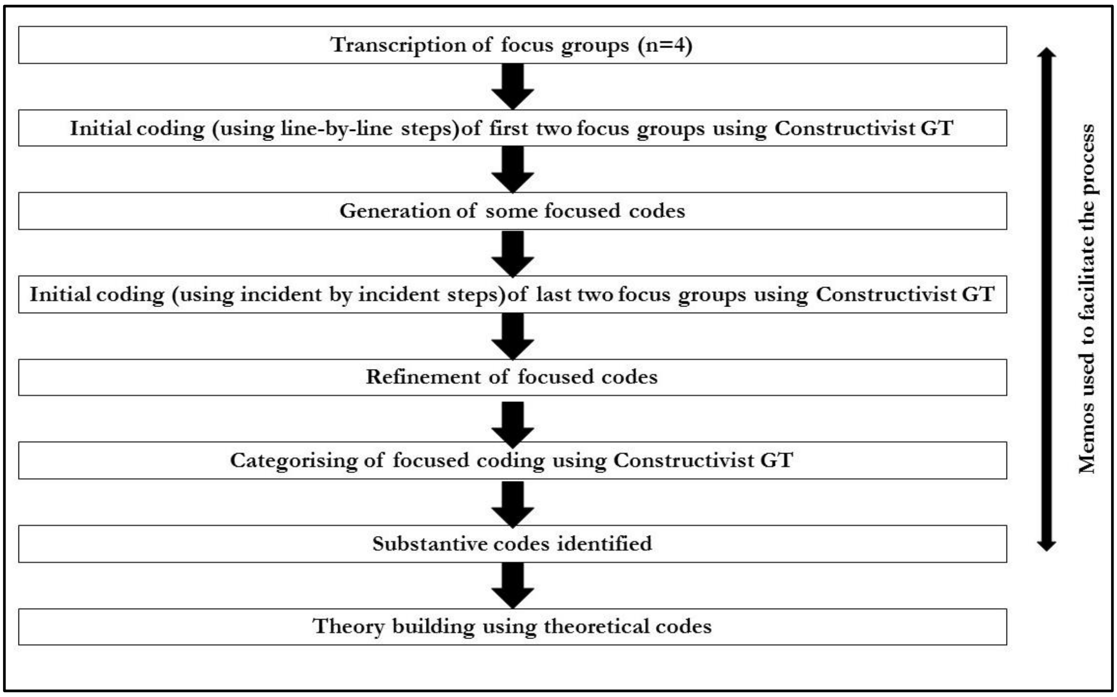


Figure 5-1 Summary of theory generation using a principles of Constructivist GT

5.2 PRESENTATION OF FINDINGS: TEACHERS' PERCEPTIONS OF SCIENCE OUTREACH PROGRAMMES

Birks and Mills (2011, p.40) describe memos as "the cornerstone of quality", whereby this process allows the researcher to record thoughts and feelings, along with insights and ideas about the data they are processing. This is also described as a fundamental process of any form of GT (Cohen et al, 2018), as this process is likened to the mortar that holds the data together. Birks and Mills (2011) also consider this process to heighten an individual's theoretical sensitivity, which is required when processing what the data illustrates. Therefore, whilst this memoing process is important, Charmaz (2006) advocates freedom, flexibility and spontaneity as part of this process.

Within this phase, many initial memos were handwritten in a different colour pen when coding each transcript (see Appendix L: Examples of focus group transcript with examples of Initial codes and memos), and these hand written memos were further categorised and presented within the remainder of this chapter. The researcher developed this system of memoing because it allowed initial thoughts to be articulated in real time and prompted the researcher to reflect frequently on the emerging codes and categories. Along with memos being part of the iterative approach that forms part of GT (Urquhart, 2013), it benefitted the design of this phase of the study as these memos further rationalised changes made to the models between the wave one and wave two focus groups. It was also of personal benefit to the researcher, as it meant that during the writing process of the thesis, internal dialogues and experiences that may have occurred several months previously had been documented. Thus, allowing the researcher to reflect retrospectively on these findings, which further informed the GT process (Birks and Mills, 2011).

The generation of theoretical memos centred upon a reflective approach to the data and was refined throughout. Charmaz (2008, p.398) described in her social constructivist approach to GT, "the relativity of the researcher's perspectives, positions, practices, and research situation and the researcher's reflexivity" are considered. Thus, the researcher in this study understands that their previous role as a teacher, previously engaging with science outreach events, may have impacted upon the GT process. Constructivist GT thus acknowledges that the substantive and theoretical codes presented, although adopting the systematic process, are still a social construct of the researcher (Charmaz, 2008). These theoretical codes then resulted in the formation of substantive theories which are presented within the next section. The initial coding was done by hand on copies of the transcripts and memos were used to assist in the refinement of codes into categories. Table 5-2 presents an extract of this process and illustrates how the researcher did this:

Table 5-2 Example of the how a category was developed from initial coding

Data Focus Group 3	Initial codes	Focused codes	Category
C: Like you said, kids see us as teachers so, when we're talking they don't, I think they think we're just obsessed with the education rather than it actually linked to careers and so I think when someone actually comes from industry as well it helps or a university … C: It makes it real doesn't it? B: Yeah. E: Our students are very blinkered and they've got no aspirations out of their own postcode and out of their own family. So if dad worked at one industry, that's all they know and they don't know anything else and so I think it opens their eyes a little bit that there are other opportunities out there.	-Careers -Not just university links -Real-life context -Raise aspirations -Contextualise science -Broadens horizons	Promotes science Nature of science Mind-set	Changing minds

The refinement of this category was informed by the process of memo writing. An example of a memo that assisted with this process is shared below:

When focusing upon initial codes such as *not just university links, broadens horizons* and *raising* aspirations these demonstrated how science outreach programmes may assist with learners' perceptions of science. As these perceptions are reconstructed then this could cause them to 'change their minds' about their current views of science and pursuing a career within the field. Thus 'Changing minds' as a category explores how an experience may have the potential for individuals to think differently about either themselves, their futures or science. The data provides a number of examples of how participants found that these events were able to provide knowledge regarding potential careers and "open their eyes a bit" to what science is like in real-life. This means that the typical stereotypes of science can be re-constructed and learners who might have had one view about what science is and what it is like to be a scientist, may change. It's not surprising that this was a discussion point for the teachers as three out of the four schools that participated in the focus groups had an above average number of disadvantaged pupils and the conceptual framework that underpins this research presents how parental SES can have an impact on career aspirations (Gutman and Schoon, 2012). The data provides lots of anecdotes of how participants felt that science outreach could have this impact, but it also presents the idea that science outreach is about 'real-life' and school science is not. This also links to other memos regarding the 'school' politics of being involved in these programmes.
Memo 1: Example of memo use to refine codes

It shows how focused codes were able to be refined into categories and it also began to link to other memo topics which shows this approach is developed through exploring these relationships. In the instance of using constructivist GT these codes are referred to the immediate coding stage of focused coding and categorising using the initial codes, which are exemplified below in *italics* (Charmaz, 2014). This is summarised in Table 5-3 and the complex relationships between these categories are depicted by the arrows between categories in Figure 5-2.

Table 5-3 Presentation of focused codes and categories

Changing Minds	Positives Impact	Negative Aspects	The teachers	Logistics	Reasons for engaging	The learners	The outreach programme
Mind-set	New experience	Lack of time	Platform for CPD	Required support	Rewards	Target specific groups	Approach and content
Nature of Science	Amplifies Feelings	School politics	Time constraints	The design	New experiences	Opportunities for all	Links to impact
Inspires	Adds value	Negative feelings	Reasons for engagement	Pragmatic problems		Possible impact	Rationale
Promotes science	Raises science profile	Ill designed programme		Suggestions			
	Provides potential						

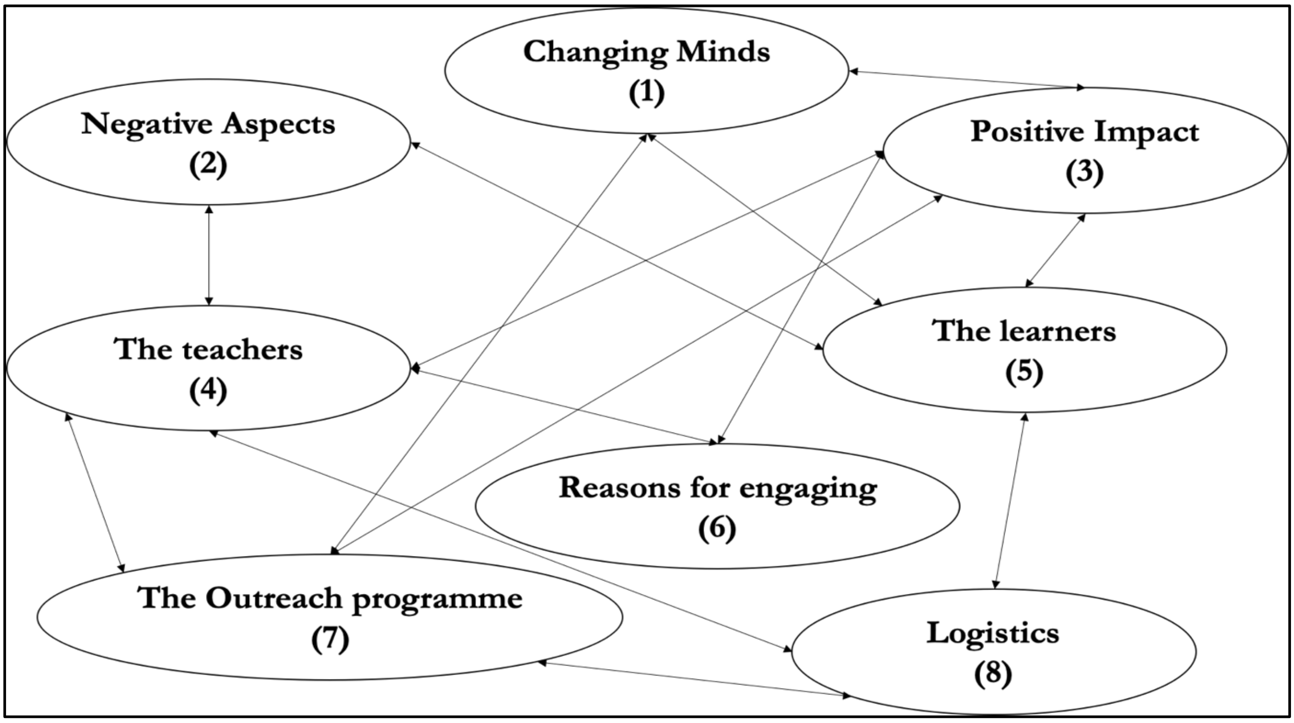


Figure 5-2 Relationships between categories

5.2.1.1 Changing Minds

The development of this category is presented in Table 5-2 and Figure 5-2 and also refers to aspects of the data which highlight how science outreach experiences can *raise self-esteem* and provide *insights into their future*. The participants within the focus groups discussed how these experiences can be more than just an extra-learning opportunity but also described by Focus Group (FG) 1 (secondary science department) as a way to "go out of their comfort zone" due to "self-confidence issues and self-esteem and that's part of the reason that we're trying to get them on trips". Therefore, this category connects to the other categories 'positive impact', 'the learners themselves' and 'the outreach programme'. For example, a benefit described by FG 1 identified how the outreach activities *increase confidence* and how they will *take away something-but not what you always expect*. This however is dependent on the learner themselves as it is *not the same for all pupils* and *some groups of students are reluctant* or *nervous*. However, with *well-planned outreach activities,* the design of the programme could anticipate working with specific groups of learners to *make it relatable*. This is captured within FG 3 who exemplify this by stating "it gives them [students] that opportunity to maybe raise their aspirations because as you said, a lot of our kids have got such low aspirations because no-one in the family's been to university".

5.2.1.2 *Negative aspects*

Within each FG, participants not only shared their positive experiences, in addition they recognised the limitations and conflicts that may arise when engaging (or trying to engage) with outreach events. These negative 'feelings' may have an impact on both the learners and the teachers and are generally related to a 'lack of time', 'school politics', 'negative feelings' and an 'ill designed programme'. For example, as there is *less science since it is no longer a KS2 SAT* it means that there will be *differences between schools* in terms of how much time is spent teaching the subject, and the importance of these informal learning experiences. This then meant that *some students may demonstrate 'bad' attitudes* at these events and have *low aspirations* or *low engagement* and because of differences between schools and 'school politics' there may be a *miss-match in opportunity* for learners to experience these events. Another aspect that links to this category that was described in all focus groups was *curriculum constraints* and *exam pressure* which meant teachers deemed there to be insufficient time for these activities. FG 2 described a range of activities they had engaged with, but all of these were placed in the context of the primary science National Curriculum

(DfE, 2013) as they stated that the "national curriculum is king". Even when sufficient time was made to partake in outreach activities, some participants alluded to the notion that these events were *hands-on* and *fun* and the participants were just the 'boring teachers'. These ideas link to the tentative relationships between schools and providers discussed in Figure 5-2.

Seemingly, as much as teachers do value and see the positive impact of learners engaging with science outreach activities there is a slight tone of resentment. For example, FG 3 discusses the teaching of thermos-softening polymers and the hands-on activity provided by the outreach activity and how that "it makes us look more boring. So the outreach, it's good and makes it all exciting…..and then the next day they come back to us and we do a normal lesson". The participants from the same focus group continue to describe how "kids just see us as teachers" and they believed that the learners did not respect them when they discussed possible careers etc. Teachers were also able to share some of the times that these outreach events had not worked and they discussed how the providers did not know their target audience and how students had "switched off and they're messing about" and that it was "soul destroying". Therefore, as the teachers are gatekeepers to these types of experiences it is important to ensure that they feel valued as part of the process and the design is suitable for their pupils. It would seem that a more collaborative approach or one in which teachers could replicate key activities would assist with this. There is always a sense of "I would love for them to be able to see it but in school we haven't got it" or we "couldn't do it even if we wanted to" in these discussions.
Memo 2 Relationship between science outreach facilitators and schools

5.2.1.3 Positive Impact

It was encouraging to note that all participants within the focus groups, were able to share positive experiences being involved with science outreach activities. The initial coding was focused upon the following benefits of; 'new experiences', 'amplifies feelings' towards science, 'adds value' to the current learning, 'raises the profile of science' and the 'positive potential' of these programmes. The 'positive impact' category links to the idea of 'changing minds' and 'reasons for engaging' with science outreach programmes but the 'positive impacts' are specifically placed in the context of 'the learners themselves' and 'the teachers'. All focus groups discussed how taking part in these programmes could raise the overall profile of science in the school and importance within the curriculum, Memo 3 below highlights the nature of this.

The idea of raising the profile of science appears often within the focus groups and refers to simply making science more prominent for the individual learner or as a subject within the school. For example, "it raises the profile of the subject a bit because like, it's not that long ago that there was an expectation that schools did a certain amount of hours every week…it's definitely been marginalised". It can also help to fill a void such as promoting science as a viable option when parents of individuals are unable to provide these experiences to show how science is not just happening in their school. Participants highlighted that science outreach can also help to raise the profile of their own school as "we're competing with other schools…they go out and see the kids from grammar schools or private schools and they're able to compete". Therefore, being more aware of this benefit of schools' engaging with outreach activities should be considered when thinking about the purpose of the programmes as it makes the *time constraints* associated with the organisation more worthwhile.

Memo 3 Raising the profile of science

When participants discussed how these outreach initiatives can *provide opportunities*, *new interactions* or *access to new spaces and materials* they were also able to discuss how the programmes can enhance the learners' current experience of science as the learners *talk about the event afterwards* as they are *memorable,* and potentially assist with current 'issues' within the school. For example, when Focus Group 4 were discussing home-school relationships they highlighted how to get 'parents on board' as this is really important for the school. When considering the inclusion of parents within the model they discussed how important this was but noted that "you want them to spend quality time together". Therefore, this was later considered within the modification of the model (see section 5.3).

5.2.1.4 The teachers

The data from this research asked teachers to focus upon their perceptions of science outreach activities with all questions linked to the impact on their learners. However, what became notable from the first stage of this study, and subsequently discussed in all focus groups, was how it had a huge impact on the participants themselves. Some of the focused codes in this category link to science outreach being a 'platform for CPD' for the teachers and noted the 'reasons they engage' with these programmes. This demonstrated how this category relates to the 'positive impact' that it could have upon both 'the teachers' and 'the learners themselves'. The teachers are an integral part of the success of these outreach programmes and as a result this category relates to most of the others. It is their values and views of the utility of these experiences which is often the reason why children get to experience these activities (Cridge and Cridge, 2013). Participants within the focus groups depict how these type of outreach experiences are valued as (re)sources to *provide information* and that having *follow-up activities* can make the experience more sustained. Memo 4 summarises these ideas.

It was discussed in FG 2 that they would expect the science outreach activity "to do something that you couldn't have done as their teacher". Whilst this could be seen as a negative due to previous ideas about relationships, in this context it reaffirms that even though the question was originally about the programmes for the learners, the participants (who were all teachers) related the experience to themselves. In many instances where teachers are attending these outreach events, they not only have a chance to collaborate with professionals from other sectors but also meet other schools. Focus Group 4 listed these benefits "being able to work alongside colleagues as well is great isn't it?", "having time to talk", "having those professional conversations", "it's sharing good practice". Also discussed was how, at these events, equipment like data loggers were being used and they could find out about how they could use an on-line App in a classroom context. Other participants also discussed how it was a great opportunity to work with the laboratory technicians, although they did highlight that these experiences were hard to come by. Therefore, as teachers are keen for the programmes to benefit themselves the designers should really see both the learner and the teacher as an equal stakeholder. If programmes could be designed in this manner, then it might assist with making teachers feel more valued and thus more willing to give up their 'extra time' to engage with these events.
Memo 4 Teachers being of equal important in the design of science outreach programmes

These ideas link to the barrier of 'time constraints' which is the final focused code group within this category. As previously discussed, teachers are the gate keepers to these experiences; however, even if the teacher is very open to these experiences these events take *time to organise, more responsibility* and go *above and beyond* and not given any extra time in their role to do so. Participants described how they knew that some colleagues in other schools would be provided with financial reward for taking on these extra roles, "which seemed unfair", and again this links to previous ideas about the disparity in opportunities to experience these events. Therefore, the design of these programmes as such should aim to minimise administration tasks for teachers to entice them to attend these events.

5.2.1.5 The learners

This category includes ideas about science outreach programmes having the potential to 'target specific groups' of learners, how they should provide 'opportunities for all' and the 'possible impact' this may have on the learners themselves. These ideas are connected to several other categories which focus upon the impact these activities can have and the logistics of involving the learners in the first instance. Participants illustrated with their examples that the learners have received a *diversity of experiences* and these were *not the same for all pupils*. Whilst considering the programmes they had encountered, they also described how some pupils showed *reluctance* to participate and they could be *nervous*. These ideas particularly linked to *pupil premium* students but did say that it was *dependent on the individual* as often *high ability students might have more positive experiences*. Thus, it is worth considering that even with a well-designed programme and a pro-active teacher the learners may not be receptive due to multiple factors. FG 1 described how they have seen how a variety of different learners engage with outreach activities and proposed that the engagement levels did correlate to which 'group' the learner may belong to. For example, it did not matter if a learner was classified as a 'high achiever' or 'disadvantaged', as what was more important was "if you've got an enthusiastic pupil and you take them away they'll embrace it all and engage with you fully" regardless of their 'labels'. When considering the 'possible impacts' within this category it is more than just thinking about the benefits and limitations; it's how different groups of students respond beyond the initial aims of the programmes. For example, a participant described an activity focused on disadvantaged students and how "I went to London yesterday and one of the girls had never been on a train" and "you are taking them out of their comfort zone". Therefore, these outreach experiences can be stressful and present broader challenges than was maybe first anticipated. This should also be considered when looking at widening participation programmes as barriers to engagement may not initially be obvious.

Whilst participants considered the impact on the different groups Memo 5 informed the creation of the focused code 'opportunities for all', it considers participants' ideas about who is selected to experience these activities. Therefore, whilst it is important for outreach facilitators in science to focus on this more socially disadvantaged group, they may want to consider other criteria too when working with schools.

Participants were quick to identify how disadvantaged learners, who are in receipt of 'pupil premium' funding, were often a focus of outreach activities. They were also happy to discuss why they are beneficial

to the learners considering how they *don't get experiences at home* and that there is often "ring fenced money and we can put bids in to get the pupils on the trip for free". Whilst this is encouraging to see participants in all focus groups describe the benefit these experiences have on all learners it was worth noting that one participant stated, "I think also for all children, not just pupil premium, it's the parental input". This idea links to the conceptual framework proposed within the structure of the research (Gutman and Schoon, 2012). Participants highlighted that sometimes pupil-premium learners out-perform those not within this group and describe how they feel that using 'pupil premium' is not an exact measure of social deprivation as they discussed how all pupils in a school come from the same deprived area; this supports the ideas of (Gorard et al 2019) on how this group is often identified in schools. It could be that children in similar situations just miss out on being supported in the same way because of a technicality or their year group. This idea reflects an Ofsted (2013b, p.3) speech entitled 'The unlucky chid' as it presents that it is an "educational lottery" as to the area in which a child lives and what school they attend.

Memo 5 The unlucky learners

This phase also asked teachers to specifically focus on learners with a low SES and how the proposed model could be most impactful for them. This refined model is presented in chapter 6 but the discussion from the focus groups provided further codes which were used in the formation of this category. Participants were asked to focus upon pupil premium students and what aspects of the model were most significant for these individuals. All focus groups highlighted the 'parent section' of the model and how the inclusion of this was a powerful way to 'target specific groups' and the 'possible impact it may have'. These thoughts are summarised in Memo 6.

Each FG discussed how engaging parents is something that they find difficult as a school but how "getting them on board" can be mutually beneficial for school/home relationships. FG 3 discussed how engaging the parents could be a way to *raise aspirations* for learners, particularly those from lower socioeconomic backgrounds. The participants discussed how, if a science outreach event meant that the pupils could take something home, then they could show their parents what they made and this increases the chances of parents wanting to know more about it. They summarise that "if we can get the parents on board and kids engaging and chatting with their parents about something…I found that the kids were more interested in school". This could make the event more memorable, especially when the outreach activity may have been a stand-alone event. It also supports ideas that parental encouragement can have an impact on choices (Gorard and See, 2009; Gutman and Schoon, 2007) and this particular group of pupils may not have as much encouragement in science at home. FG 2 also described how they had parents who were employed in science, volunteer to speak to the learners' in-situ, which also allowed

pupils to find out about careers in science. This links to other ideas about the *importance of role-models* as parents may be less able to provide this support, so using other familiar parental figures may make these events more relevant and relatable (Hodson, 1998). Whilst participants were able to describe the positive potential of further engaging parents, they were all in agreement that pragmatically, it was hard to do so.
Memo 6: Parent power

5.2.1.6 *Reasons for engaging*

This category is relatively small in comparison to others and does not contain any focused codes as it highlights what motivates 'the teachers' to be involved with outreach endeavours. It provides additional insight for the designers of the programmes, as it evidences how teachers use these opportunities as *reward trips* and to *make it more memorable* by often *providing opportunities they wouldn't get at home*. These codes may align also those in the 'positive impacts' category, but these codes also contextualise teachers 'reasons for engaging' with outreach. It was also highlighted by FG3 that the deliverer of the outreach activity can impact upon their decision to engage. They discuss a long-term engagement with a chemistry outreach programme and state:

> You've worked with them for so long that you know what you're gonna get and you know that these people are used to working with kids, but then it's that danger that when you get a kind of one off and you're going 'I hope its's gonna be good because if not I know it's embarrassing. (FG 3)

This reaffirms the importance of the relationship between the facilitators and the school and it is those programmes that can foster a partnership which can be more successful. The teachers can *tap into the expertise of others* and *take away something* which adds to their reasons to want to attend these events themselves; this links to Memo 4.

5.2.1.7 The outreach programme

The focus of this category involves codes which focuses on the 'approach and content' and 'rationale' of science outreach programmes and any ideas about 'links to impact' in terms of the delivery of these events. The relationship between other categories focuses on the positive impact and about how outreach can 'change minds' as these theoretically have the desired impact of the programme. It also reinforces that the outreach programme itself needs to appeal to the teachers as gatekeepers to the classroom. In several focus groups the participants were able to discuss a range of different types of outreach activities they had engaged with in science. They agreed that it was *easier to do in school* but "I don't think the one in school has a big an impact though…just because it's familiar for them and it's not taking them outside their comfort zone much". Thus, if the 'approach and content' is considered from the start, programmes, whether inbound or outbound, experiences can be impactful; these are highlighted in Memo 7.

In the participants' celebration or critique of their reflection of experiencing different outreach events in science they have indivertibly presented a list of ingredients for having a successful programme. These 'desires' are taken from several initial codes but collectively provide useful insight for those who facilitate the design and delivery of the activities. This allows the research to present the following recommendations:

- Appeals to all abilities and needs to be well planned
- It should focus on developing skills that link to the curriculum rather than too much focus on knowledge (this is the focus of the formal science curriculum).
- Should encourage lots of schools to be involved with the events as it promotes networking and healthy competition.
- It should provide unique experience but also substitute for missed opportunities.
- It should make the learners feel a sense of 'wow' by being hands-on, allowing them to do it for themselves, using new equipment and be relatable.
- The facilitator should have a good understanding of the learners.
- It could provide support for schools such as, during science week or being part of transition projects, involving parents to enhance links between home and school.

Memo 7 What should be within the science outreach programme itself

Another consideration regarding the impact of the outreach programme itself is that it is deemed to be *less impactful if it is a stand-alone event* as the *longer the event-the more memorable it is.* This can be difficult to organise (which will be discussed in the next section) but even if it's a little more sustained participants recognise that it can be more impactful "if it's just one block of a day it sticks in [their mind] more than one lesson." A strong rationale is important and provides purpose for each activity as it should be seen to be *bigger than just a science trip* for some groups of learners and maybe *outline careers that don't just link to university*. Ultimately for the teachers, it should also promote *what science outreach is.* When asking participants what the phrase "science outreach" meant to them it was outlined that "it's the first time I've really heard it," even though they then discussed a number of examples they had experienced.

5.2.1.8 Logistics

This final category focuses on the 'pragmatic problems' and the 'required support' for schools to be able to engage with these science outreach activities, considering the 'suggestions' of some of the participants. 'The design' considers the bigger picture of the design the outreach programme itself; thus, having a close relationship with this additional category. In section 5.2.1.4 teachers previously discussed their 'time constraints' and logically the main considerations were: *time, cost, teacher workload* and *whether the head-teacher is supportive* of these endeavours. This is discussed in Memo 8.

Within every FG there are several examples of participants being involved with science outreach activities even though all of them discuss how it can be difficult due to the costs and demands on teacher's time. It's an extra responsibility which is notably made easier if the head-teacher supports these activities. For example "…that's quite expensive and our head is really good with that but I know some head teachers, it's down to budgets and funding and it's at the discretion of them" and "our head has been really supportive in making sure we can go on it, but again, once we have we're expected to write a news article for it". Therefore, even if teachers are fully on-board and are prepared to take on more responsibilities to organise these events then without the support of the head teacher then it may not happen. Therefore, it has to be beneficial not just for the learners, but also the school and benefits should be communicated clearly to maximise the chance of engagement.
Memo 8 The head teacher as the 'gatekeeper's' gatekeeper

Access to events is often affected by pragmatic issues as *location, health and safety* aspects, *the frequency of the events* and *whether they are voluntary or not*. This last point could impact on the number of learners who chose to engage with these events. If engagement is voluntary, then it must be considered whether it serves only to enthuse learners who are already enthused. However, within Focus Group 4's discussion of a successful event, this involved going into a local secondary school. For primary schools this would be a practical way for an event to be more impactful as it takes place in a different setting. It would also be more appealing to a head teacher who can see the benefits of working with partner schools. The outreach providers could utilise these facilities which could also reduce location anxieties. It was also described how "they gave us a box that we could then bring into school and it was a fantastic project…we loved that and then the box just stopped, we didn't get them anymore". Whilst this could be a cost related consideration it shows the value teachers place on being able to *take-away something* which in turn could be a solution to making stand-alone events more impactful.

5.2.2 BUILDING THE THEORY

Birks and Mills (2011) explain how diagramming is an effective creative tool to organise and connect codes and categories. The diagrams within this phase depict how early coding was refined and latter diagrams show the developing theory (Appendix N: Summary of stage 1 pilot study). The use of these diagrams particularly assisted with the advanced coding stages to be able to consider relationships. Strauss (1987) discusses the use of *integrative* diagrams that can build upon one another and assist with defining relationships between categories. Advanced coding is the stage in which data can be transformed into theory (Birks and Mills, 2011); this consists of generating substantive codes which conceptualise what an area of research consists of and theoretical codes which consider how the substantive codes may relate to each other (Glaser, 1978). Urquhart (2013) agrees as it is through exploring the relationships between categories that theoretical coding develops and it is these relationships that are crucial. Charmaz (2006) discusses how it is particularly important to be reflective during this final process and therefore theoretical memos assist with this as these memos can elaborate on ideas (Urquhart, 2013). This process mirrors the ideas of 'abduction' whereby intellectual processes determine connections and makes a mental leap between these known ideas (categories) (Reichertz, 2010). Reichertz (2019) describe how this process requires both logic and innovation to discover new ideas.

GT differs to other qualitative methods as it seeks to understand the relationships between themes and use them to generate theory. Urquhart (2013) illustrates this as a 'brick wall' analogy with the 'concepts' being the bricks and the 'connections' as the mortar. These

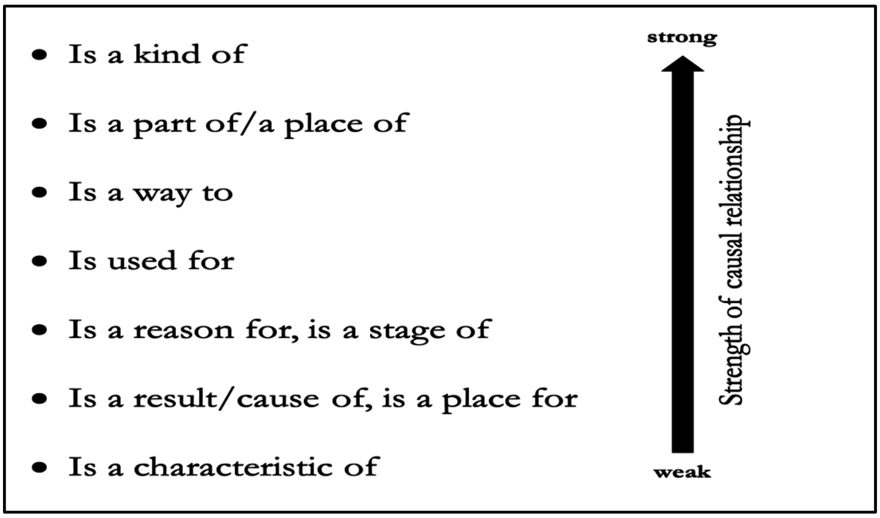


Figure 5-3 Adaptation of Spradley's (1979) semantic relationships from Urquhart (2013, p.44)

‘connections’ are also the theoretical codes. Glaser (2005) presents 23 ‘coding families’ for this stage, whereby these can be used to explore the relationships between these concepts. There are, other guides on how to link categories present other qualitative methods, such as Spadley’s (1979) semantic relationships. These are nine relationships that can exist between domains and have a varying degree of whether the causal relationships are strong or weak; however, they are presented simply (Urquhart, 2013) and are presented in Figure 5-3. Therefore, the process of building these relationships has a degree of flexibility and utilising both these frameworks, aligns to a constructivist GT approach. Thus, the substantive codes have been refined to those presented in Figure 5-4 on the next page.

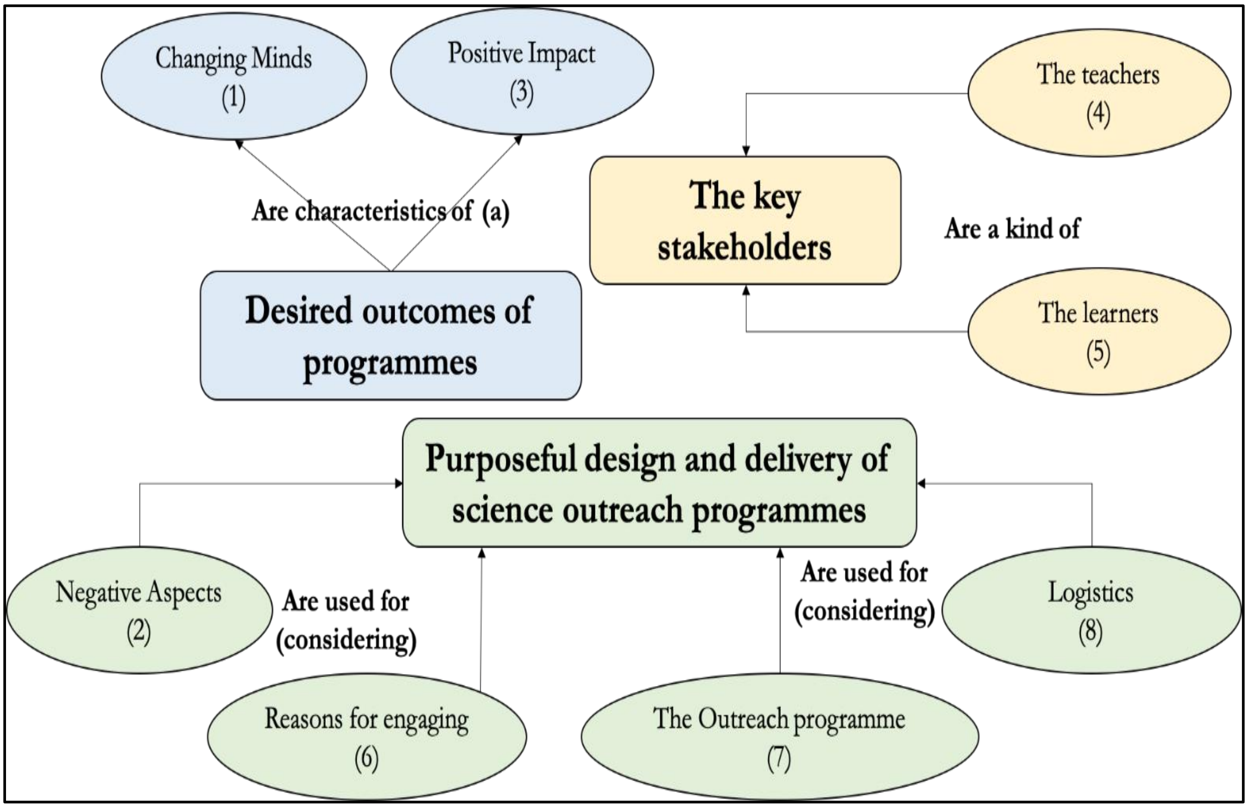


Figure 5-4 Presenting the substantive codes

As an example, Memo 4 (see section 5.2.1.4) was the driving force behind the substantive code ‘the key stakeholders. The formation of the other two substantive codes are depicted in Memo 9 and Memo 10.

When considering how to make science outreach programmes more impactful, the designers of such programmes whether they are universities, companies or other schools, need to reflect upon what has not worked so well in the past to be able to learn from this and improve future activities. In the same spirit, it needs to be understood why groups do chose to engage with these types of activities in the first place and to ensure this becomes a 'hook' to potentially engage a larger population.

Using teachers' perceptions of their past experiences can provide this type of information and help to refine programmes as described by Glover et al (2016). Motivational theories strengthen this view as these programmes should make stakeholders want to be involved: For example, Eccles et al (1983) presents the idea of 'expectant-value theory' which draws upon ideas of expectancies and values, which links to achievement. Urdan and Maehr (1995) discuss present 'achievement goal theory' which directly links to ideas from Eccles et al (1983); however, the focus is placed upon why someone wants to achieve a goal. This requires an understanding of a teachers' individuals' values and beliefs as the core to making interventions like these a success.

When considering the teacher in these types of programmes, understanding the 'gatekeeper's' perspective is crucial. Teachers within the focus groups readily discussed what they believed a programme should to do and looking Therefore, in turn, if this happened it was seen that teachers were more encouraged to engage in these future events. Therefore, understanding these and ensuring that the programme is accessible and purposeful for the children they teach, could also contribute to whether they chose to engage with the outreach activities or not.

Memo 9 The importance of a purposeful design and delivery

Considering the categories presented at this point, two of these that stand out are 'changing minds' and 'positive impacts'. It is arguable that these are the ultimate goals of many stakeholders. Participants within each focus group presented many benefits of being involved with science outreach events and it is important that future activities continue to demonstrate these. However, most of these science outreach initiatives have other agendas such as to 'widen participation' in science or even as a recruitment drive for institutions. Sadler et al (2018) describe how university-led outreach is a fast-growing sector in addressing the social and civic responsibilities of HEIs. Boyer (1996) also explains how HEIs involvement in these types of activities also contribute to the future economy in many different countries' governmental agendas. Thus, the idea of 'changing minds' is also at the forefront of the purpose of science outreach activities. Therefore, having a key understanding of the audience of these events and having clear outcomes can inform what needs to be part of the programme itself.

Memo 10 What is the desired impact of these science outreach initiatives?

At this point the researcher drew upon a 'critical friend' to discuss these substantive codes and their relationships. Urquhart (2013) advocates this process not only to add a layer of rigour to the process but also to check that the emerging ideas and theory are understandable. As the feedback from this 'critical friend' was concurrent with the information presented, the relationships between the substantive codes were theorised. Glaser (2012) advises theoretical codes will emerge from the data and will assist with integrating the theory. Whilst this is advisable, if coding families or something similar are utilised, this may force a theory down a particular route (Urquhart, 2013). Furthermore, Glaser (2005) stresses that it is better to have no theoretical code than to have a forced one. Therefore, the researcher became familiar with a range of theoretical codes and considered the relationships and drawing upon knowledge of these codes. This is fitting with using principles of constructivist GT as it has some flexibility in approach to this final stage of coding; thus, the researcher focused on the more simplistic framework of Spradley (1979). However, upon doing so it was encouraging to see how they would also link to Glaser's (2005) families. This allows this chosen qualitative analysis to go beyond the descriptive level (Flick, 2019). These codes are presented in Figure 5-5 and explained

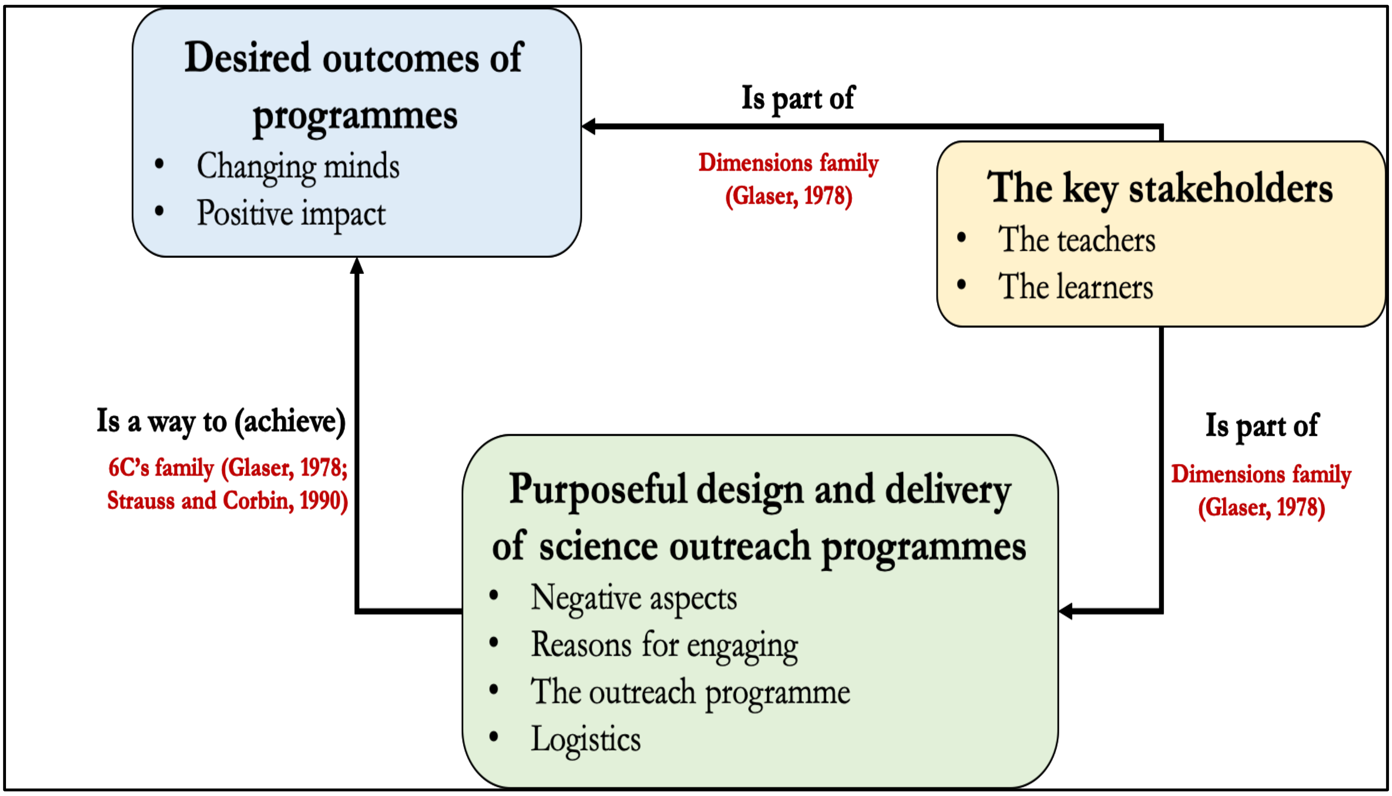


Figure 5-5 Presenting the theoretical codes

in the theoretical memos below which are formed from the relationships between substantive codes.

Theoretical Memo 1: The key stakeholders are part of purposeful design and delivery of science outreach programmes.
This idea became more important throughout each FG as participants drew on experiences where the target audiences had not been considered and thus the outreach event was not deemed to be successful. FG 3 provided a detailed experience of an event that did not have a positive impact on all pupils who attended: > Some [the learners] of them are disaffected from education but some of them just can't do it and it's because you don't know your target audience and when you do a classroom practical base, that's fine, cos we've hand selected those students and put them in front of you and said 'these are the ones we want you to push' but when it's just generic, you're losing them. I think outreach is great when it's targeted with us cos we know them best […] there's never time to do lots of differentiation but I think from an outreach point of view it needs it. (FG 3) This example summarises the importance of both the substantive codes and why they are related to one another. It re-affirms the importance of having a well-designed programme that does consider 'the learners', which is linked to one of the 'key stakeholder's. It also emphasises the importance of 'the teachers', and their views o should be included in the design of the programmes so that it becomes collaborative. This approach means that teachers feel more valued as part of the programme; this can improve the quality of the programme itself and also assist with addressing the 'us v them', which was an idea explored in Memo 2 (Szteinberg et al, 2014; Illingworth & Roop, 2015). It is observable from the extract from FG3 above that they were not impressed with their experience of the science outreach programme and drew upon what is expected in their own practice and how it is not replicated here. This idea draws upon the initial understanding of what outreach events are and how they are different to formal education. Dolan and Dolan (2008, p.1) provide their definition of 'outreach' as "a systematic attempt to provide services beyond conventional limits, as to particular segments of a community". This illustrates how these events do usually extend 'conventional limits'-which in this case would be the requirements of formal education, but it does not mean that it should not take account of them. Differentiation in education is a requirement of a teacher to be able to ensure that their teaching is inclusive (DfE, 2011). Thus, understanding the teacher and what they expect to 'be part of' (Spradley, 1979) the outreach activity is a crucial *dimension* (Glaser, 1978) of the structure of the science outreach activities.

Theoretical Memo 2: Purposeful design and delivery is a way to achieve the desired outcomes of programmes

A common aim of many of these programmes are to inspire groups of students to choose to remain within the field of STEM (Sadler et al, 20018). Some of the impact related to this is captured within the category 'changing minds' and other examples of the benefits of engaging with these programmes depicted in the category 'positive impacts'. These collectively became the desired outcomes of the programmes. Whilst these ideas were exemplified within all the focus groups it was also clear that *the way to* (Spradley, 1979) achieve this was through a purposeful design and delivery of the programme. Participants represented this relationship below:

> The projects are planned really well by the organisers, they do it really subtly so it doesn't say on the Power Point 'today we're doing team work', it's just, like the soft skills that they're focussing on throughout each week, they [the learners] don't realise they're building it up and the resilience but at the end of it you can see and I'm not being, over the top but a dramatic difference between them and, like, a few of them obviously have more of a light bulb moment than others, but generally if the project's been planned well by the organisers, like the people we get in to help us do it, it's a massive impact on pupils.

It is clear from this quote that having a well-planned event can be impactful. This is also true when considering specific student groups which would be key to a 'purposeful design and delivery of the programme' and is explained in *theoretical memo 1*. When focusing on the delivery of these events as *a way to* (Spradley, 1979) achieve the desired outcomes of the science outreach programme understanding who the target audience and the facilitator is, is instrumental. For example, 'the learners' might represent different homologous groups and the facilitator who delivers the activity needs to have a good understanding of this as participants outline:

> The role models […] female speakers talking about what they do because quite often the pupils don't see that the science they're doing in the classroom will lead to anything but to see somebody who's talking about things that they're learning about at the moment, in a job.

The focus group went on to describe how they have seen the positive impact from this 'women in science' event, thus the delivery had been deemed to be successful in terms of the desired outcomes of the event. However, when considering the design and delivery and to make it purposeful, the facilitators also need to think about what the priorities for the desired outcomes are for their audiences. It has been noted that there are many different agendas of the programmes themselves, but these may not always align with the outreach recipients and their priorities: *I think a lot of the trips' focus that come to us are about getting pupils to Uni, I think like that's probably the aim of the provider but it's not always the outcome,* It was also described by participants that the "curriculum is king" and therefore, this aspect should be considered by those who design these programmes as whilst it might not be the provider's priority, it is a priority for the schools; which as key stakeholders are *part of* (Spradley, 1979) the purposeful design (see *theoretical memo 1*). This idea is further captured in the extract below:

> I suppose coming from outside you follow a school scheme of work, so I think when you're getting people in you're thinking about your curriculum in general.

Thus, including considering stakeholders as a central part to shape the science outreach programmes *is a way to* (Spradley, 1979) achieve the desired outcomes of the science outreach programme.

Theoretical Memo 3: The key stakeholders are part of the desired outcomes of programmes.

Whilst, the 'desired outcomes of the science outreach programme' differ for both stakeholders it is these positive experiences that will help to fulfil the aims of the programmes themselves and encourage teachers, who are the gatekeepers of these experiences, to want to be involved. There were many examples of how these experiences could be positive for both the students and the teachers; this discussion that took place within the focus groups encapsulates how the 'hands-on' experience for the children was seen as a positive experience and how it was also useful for the teachers:

> P1 For the children, well, for ours when we went to that science fair, it was having access to a laboratory and all the materials …
>
> P2 And equipment.
>
> P1 And the technician who'd set it up was, you know, to do that in a primary school classroom is really difficult.
>
> P Using data loggers and different things that were just there.
>
> P2 So just tapping into those expertise and expensive resources and that there was enough of them, that's the other thing, so we've had data loggers before but we might only have had a pack of six so be able for everyone to do it at once.

The shows how the outreach experience was an opportunity for all and shows clearly how the key stakeholders were *part of* (Spradley, 1979) the desired outcomes of the science outreach programme. The impact on the teacher may not have been initially an aim of the programme but by involving them in the activity or allowing them to talk to other professionals is a useful CPD opportunity. This supports the ideas of Allen and Sims (2017) who depict the positive aspects of utilising these experiences for a teacher's professional development and aligns with Jeffers et al's (2004) framework regarding what aspects are commonly included in STEM outreach programmes. Participants' responses further supported these ideas:

> I think from a teacher's point of view as well it's about keeping us abreast of what's out there and them being able to inform the students.

Thus, this relationship is important as it is pivotal that the benefits of these programmes are felt by both 'the learners' and 'the teachers', as successfully impacting on both groups will promote future engagement with these types of activities.

5.2.3 Theoretical Integration and Supporting Literature

Unlike other qualitative research methods, GT allows the construction of theory by developing new insights and theoretical frameworks (Charmaz, 2017a). However, the GT process usually generates a theory mostly at the substantive level as its scope is limited to the empirical data within a particular study (Urquhart, 2019); this is one of the most common critiques of the GTM (Layder, 1998). To understand how theories arise Whetten (1989) outlines their 'building blocks', these consist of; what factors should be considered? How are the factors related? What justifies the selected factors and why should they be taken note of? And, who, where and when set the limit of the theories range? Urquhart (2013) provides a clear justification of how the GTM supports most of these 'blocks' for example, the *what* and *why* can be seen in the generation of categories and theoretical memoing, but it is the last one which is the most problematic as it links to ideas about how generalizable the theory is. A way to respond to this in GT is to extend the scope of the substantive theory through theoretical sampling. However, Glaser and Strauss (1967) also suggest that secondary data can provide this extension of the theory as data is compared to other researchers' studies. This enabled the researcher to relate the emergent theory to other research to confirm or refute existing literature, whereby new perspectives are added to a particular field. (Urquhart, 2013). This is summarised in Table 5-4.

Table 5-4 Relating the theories to existing literature

No	Theory	Supporting wider literature
Theory 1	The key stakeholders are part of the purposeful design and delivery of a science outreach programme.	**Lhussier, Carr and Forster (2015)** conduct a realist synthesis of outreach interventions as a way to improve the health of Traveller Communities. They outline how there needs to be deeper understanding of the needs of this community and then link it to the design of these interventions.
		Joshi et al (2013) discuss how it is important to understand the ICT needs of key stakeholders to enhance community outreach programmes. Their research focuses on developing a tool to be able to effectively identify the needs to inform programmes.
		Holmes et al (2014) review the needs of key stakeholders in homeless outreach psychiatric services and use these to develop performance indicators (PI) to measure the effectiveness of their outreach programme. This resulted in changes to the design of their programmes to improve the impact on many of the stakeholders involved.
		Scull and Cuthill (2010, p.72) support the inclusion of multiple stakeholders as part of this outreach design as they recognise "the need to actively involve all stakeholders who might influence an individual's decision to undertake higher education."

Theory 2	Purposeful design and delivery of science outreach programmes is a way to achieve the desired outcomes of programmes	**Dahl and Droser (2016)** outline a Geoscience education outreach programme (GEOP) aimed at K-12 (aged 5-18 years) school students designed by a university in California. They discuss how usually the programmes are costly and rely on funding, but by re-thinking the aspects of the programme, utilising graduate students and being flexible it now runs at a low cost and has the capacity to engage a large number of students. There are several examples of the types of activities offered and a rationale is provided for several of these. Case-studies of different stakeholders within the GEOP indicated that this programme was able to meet the initial aims of the programme.
		Brown (2018) describes an outreach programme designed to challenge misconceptions and attitudes of 13-14 year old students about nuclear power. Surveys and the 'draw a scientist test' (DAST) (Chambers, 1983) was used to measure whether the outcomes of this programme had been achieved and the hands-on approach and visit to an actual reactor indicated that it had been a success. Whilst the research focused on the impact on changing students minds about nuclear power, it was clear that the choice to include a visit to see a reactor was important within the design of the programme.
Theory 3	The key stakeholders are part of the desired outcomes of programmes.	**Asmus and Schroeder (2016)** relate the desired outcomes of their outreach programme to a reduction in herbicide-resistant weeds. However, they suggest to be able to achieve this there needs to be an inter-disciplinary collaboration between the stakeholders. Scientists need to work with farmers to have a more positive impact; thus, both are included as part of the desired outcomes.
		Giboney Wall and Musetti (2018) report on their more holistic approach to a family-community outreach programme which supports Latinx families in the US. This is provided by local elementary school (6-11 year olds) who explore challenges of engaging different stakeholders within the programmes. However, in doing so, they aim to understand how to overcome these to ensure the success of these programmes. Thus, all key stakeholders fit within the remit and are part of the desired outcomes of the programme to support the transition of these families with their new local US community.

Urquhart (2013, p.139) suggests that drawing upon secondary data in other fields is part of the beauty of theoretical sensitivity as "by being sensitive to theories in general, in all fields, we can enrich our categories and emergent theory from many different sources." Thus, the literature stems from a variety of disciplines, but it is encouraging to see how they link to ideas presented within this study. Some of these links are less transparent and the context of the supporting literature does make a difference, but it does help to extend the generalisability of the emergent theories.

When considering the wider literature presented, Holmes et al (2014) developed performance indicators which considered the needs of their key stakeholders to be able to decide if they were achieving the main aims of the programme. This exercise resulted in changes to practice to ensure that the outreach offered in their field was more effective. Thus, their key stakeholders were considered as *part of* the subsequent design of the programme and they also reflected upon how the key stakeholders were *part of* the programme aims. These ideas relate to theories 1 and 3 presented within this study which both capture the ideas about appreciating the needs of those who are in receipt of these activities to ensure that the outreach programme itself is fit for purpose. Joshi et al (2013), Lhussier et al (2015) and Scull and Cuthill (2010) present similar ideas in their studies as they describe, again in very different fields, cases of having an appreciation of what stakeholders want and need from outreach programmes, should inform the structure of the programmes themselves.

Giboney, Wall and Musetti's (2018) research focuses on the challenges of being able to support Latinx families in the US as part of a family outreach programme. They utilise observation, interview and focus group data to understand what can reduce the engagement with these programmes, what support does the programme currently offer and what do stakeholders wish were available. Through this exercise, it demonstrates the importance of key stakeholders being part of the desired outcomes of the programme itself. Cone et al (2013) also consider how understanding the beliefs and values of the stakeholders is a crucial step to be being able to then share new information about climate change. Although these ideas were used in the context of public engagement models, it very much follows principles of a social constructivist approach in education (Vygotsky, 1978) whereby understanding is developed and reconstructed as a collective. It allows the learner to be active in this process; use higher order thinking skills, become more engaged with the topic and promote problem solving (Haak et al, 2011). This can contribute to a more memorable learning experience (Prince, 2004). Thus, understanding literature about making learning for stakeholders more meaningful is also important when focusing on Theory 3, which depicts how these key people should be included within the desired outcomes of the programme. Asmus and Schroeder (2016) consider this collaborative approach as being crucial to the success of their outreach programme, which seeks to reduce the amount of herbicide-resistant weeds.

Similarly, to responses from the participants within this study, cost can be a limiting factor in many outreach endeavours. Dahl and Droser (2016) describe how their geoscience education outreach programme (GEOP) aims to run at a low cost but still engage and enthuse school aged children. Thus, the design and delivery of their programme needs to reflect the aim of this programme which in this case is to be more ecologically efficient. This example with wider literature does support Theory 2; however, it focuses more on the logistics of delivery not so much the design. Brown's (2018) outreach initiative focused on changing students attitudes about nuclear power and to achieve this there were lots of different types of activities included in the design of the programme. Drawing upon data from surveys and the draw a scientist test (DAST) showed that there had been notable success in being able to achieve the aims of the outreach programme, but it was the opportunity for students to see the reactor and not just learn about it that had the most impact on changing ideas. Thus, the design of a programme is crucial to being able *to achieve* its aims, but this should not be something considered retrospectively as Brown (2018) does so. Instead, Theory 2 presents that purposeful design and delivery should be at the forefront of the facilitators' minds and how it can meet the desired objectives of the outreach programme.

5.3 MODEL REFINEMENT: AN OPTIMUM MODEL FOR A MORE IMPACTFUL APPROACH TO THE DESIGN AND DELIVERY OF SCIENCE OUTREACH PROGRAMMES

During the focus groups, participants were presented with copies of the most current version of the 'optimum model of science outreach' which had initially been designed from primary and secondary data as part of Phase One of this research project. The focus groups asked the teachers to annotate the model and make suggestions about how they would change or improve it based on their beliefs (see examples in Appendix S: Examples of annotations on the models during the focus groups). This process also followed the iterative approach adopted in GT whereby there is a cycle back and forth between the emergent theories and the data to produce knowledge (Orton, 1997). After each 'wave' which consisted of a focus group in a primary and secondary school (thus, covering the 3-16/19 age range) there was an opportunity to refine the model which represented this new knowledge. These changes are summarised in Table 5-5 and the subsequent sections draw upon participant data to justify these.

Table 5-5 Summary of changes made to the 'optimum model of science outreach' throughout Phase Two

	Suggested Change	The response
Wave 1	Shape of the model itself.	Provide some alternative ‘shapes’ of the model. Flip the age categories.
	The model should provide targeted support for younger children.	Add an extra age category.
	Promotion of science jobs at a younger age.	Include this category within the younger age group.
	Need to include being practical in science at a younger age.	Include this category within the younger age group.
	Idea that all programmes should support the curriculum and do something different.	Make this visible by adding these categories throughout the model (as arrows).
Wave 2	Do not use the circular design.	Refer back to the original shape presented.
	Some of the language of the categories and practical science need refining.	Change the terms ‘working scientifically’ and ‘enhancing practical skills’.
	Idea of a ‘take-home’ activity.	Include this in the up to 12 year’s old category for parents.
	Careers should be earlier.	Add this to ideas within the first age group category.
	Needs to be clearer to understand.	Include an ‘instruction box’ for how to use the model.

5.3.1 Wave 1 Changes

There were significant changes made to both the shape and content of the model, following the first 'wave' of focus groups. These are detailed in the following sections and a small visual summary provided in Figure 5-6. Within both focus groups in Wave 1, the draft model was generally well received. Whilst suggesting how it could be improved, participants were also encouraged to see how it supported their role as formal educators; as a participant highlighted how the model "still encompasses everything, that's your science education isn't it?" Within the first focus group that took place in a high school it was also positive to see how the head of the department recognised the utility of the model to support schools "I think it's really good…if I wanted to present to my department a vision for why I would like to do trips and how it would look differently across the years I think that's really nice." This shows how the model could be

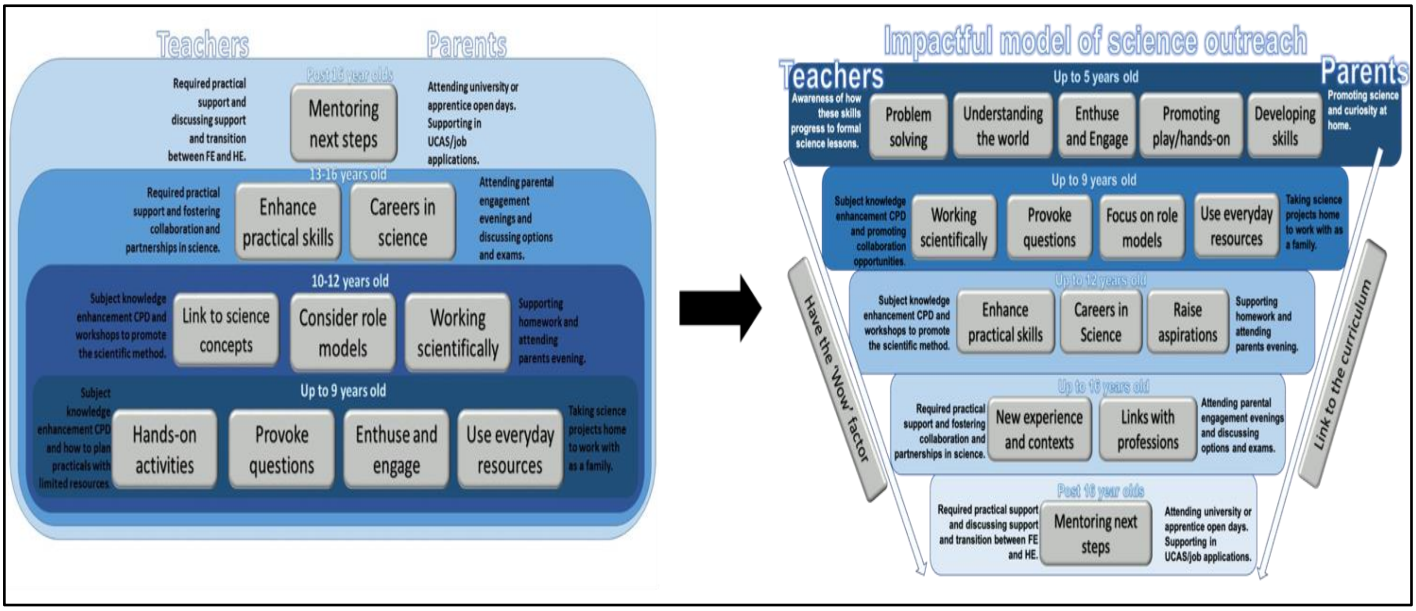


Figure 5-6 A visual representation of the changes to the model from 'draft' to the end of wave 1.

used by multiple stakeholders and it further aligns with ideas in Memo 8 regarding the required support of head teachers to be able to access these outreach provisions in the first instance. Thus, if this 'optimum science outreach model for lasting impact' is utilised by those who design science outreach programmes, it is supported by a clear rationale underpinned by wider literature and primary data from this PhD project. For example, a participant describes how "I think at the moment, like trips in most schools, you wouldn't usually think of them strategically like you have on here…we've done it accidentally". Thus again, showing how the model is useful for a wider range of stakeholders such as leadership teams in schools and facilitators of the outreach programmes themselves.

Participants also considered how they could see how categories within the model are "being built upon" and this was considered important for both the learners and the teachers. They also favoured using the term 'next steps' within the oldest age group as "I agree totally, 'cos I think if you did put access to uni or whatever then I think it would put a lot of people off". This point is reassuring as STEM careers are not only accessible via one route; Russell et al (2018) considers how university STEM courses contain many underrepresented groups, but luckily Career Communications Inc (2020) find that in the USA half the routes into STEM do not require a four year graduate degree. In the UK, there has been more funding for STEM focused apprenticeships which also makes the routes into the field more varied (NFER et al, 2016).

Participants also commented on the benefits of including both teachers and parents within the design of the model. For parents, it would provide further opportunities to engage in science activities with their child and support parents so that "they can do some fun things with their kids", linking to ideas presented in Memo 6. Teachers also liked how the model promoted school collaboration, commenting how "networking across schools is a really important part of CPD" and "I think something we could develop as a department is making better links and partnerships." Thus, further supporting the ideas around teachers being important stakeholders within the design of the programme as discussed in Memo 4.

5.3.1.1 Suggested improvements to the model

The key suggestions made during Wave 1 linked to ideas about the shape of the model, the age groups and what should be promoted throughout the programme. The participants were provided with copies of the draft of the model and whilst using these to discuss the design they were also encouraged to annotate these models with their own suggestions (**Error! Reference source not found.**). Upon introduction about the model there seemed to be confusion on how to interpret it. The 'waterfall' method of presenting the ideas (discussed in section 4.5) was not clear, as the 'age categories' seemed too discrete "what year group did you take, considering this is for 10-12 year olds?". Therefore, to facilitate with the 'waterfall' approach the age categories will be redefined and the model itself 'flipped' so that it funnels (like a waterfall) as opposed to looking more pyramidal. It was also suggested by a participant that the shape itself could be changed and this is shown in **Error! Reference source not found.**.

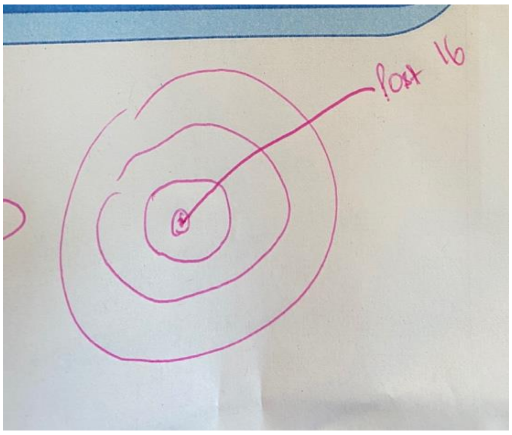


Figure 5-7 Participant's suggestion for a shape change.

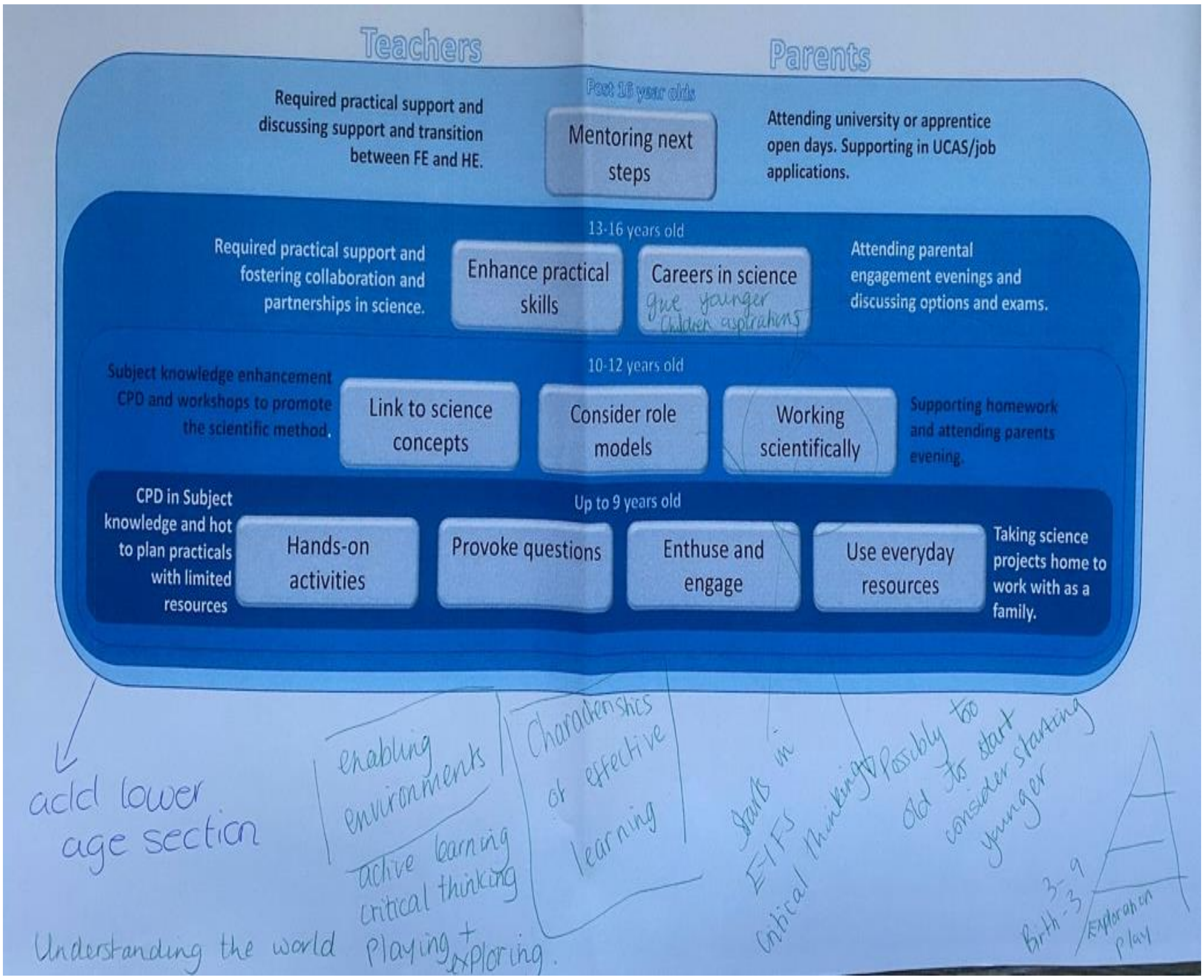


Figure 5-8 Participant's annotations of the draft model suggesting an extra age category

The aspect of the model that participants seemed to be most critical of was the first age group. A participant stated how "my first thought (about the model) is that 'up to 9 years old' is a huge age compared to other ages". It was suggested that there should be another 'layer' within the model and they also stated "I think if you did an earlier section you could get them to use the characteristic effects," this suggestion aligns with the Early Year and Foundation Stage (EYFS) framework in England (DfE, 2017). There was also s discussion surrounding the age appropriateness of some of the individual categories. Participants felt that promotion of careers needed to come earlier as it was described how children being aware of careers in science is "motivational stuff before they go to high school" as "you want these children to be aspirational so you've gotta really get them when they're young". There was also a similar discussion around the promotion of practical skills as the draft model formally introduced these ideas in the second category but it was highlighted how "we have working scientifically in [Years] 1 and 2" which encompasses the formal curriculum for 5-7 year olds. Thus, the introduction of the extra age 'layer' would support and promote outreach in science for younger aged children and allow certain categories to be moved to lower age groups in the next version of the model (see Figure 5-9).

Theoretical Memo 2 explores the relationship between the purposeful design of science outreach programmes and their desired outcomes whereby this is facilitated by aligning with formal curricula. These ideas were highlighted within the initial discussion and when looking at the model itself and how its design would facilitate these ideas. Participants reiterated how they would always have to consider their schemes of work and stated that "I don't think we would get anyone in that didn't tie in with the curriculum anyway". Therefore, it is important that the model does promote these links and that those who design the programmes recognise what may motivate teachers to be involved. It was also noted how science outreach programmes should provide *unique experiences* and "wow moments" as these novel experiences may also be what engages a school with a particular outreach programme. However, it was noted in the following exchange that:

> Participant: There's a difference between having like, a wow science show and then something that will help you with your curriculum.
>
> Researcher: So, it either needs to be wow and engaging or….
>
> Participant: [Interrupting the facilitator] I think both

Therefore, extra labels were added to the model to support these ideas and represent their importance when working with any age group. The refined model after Wave 1 is presented in Figure 5-9.

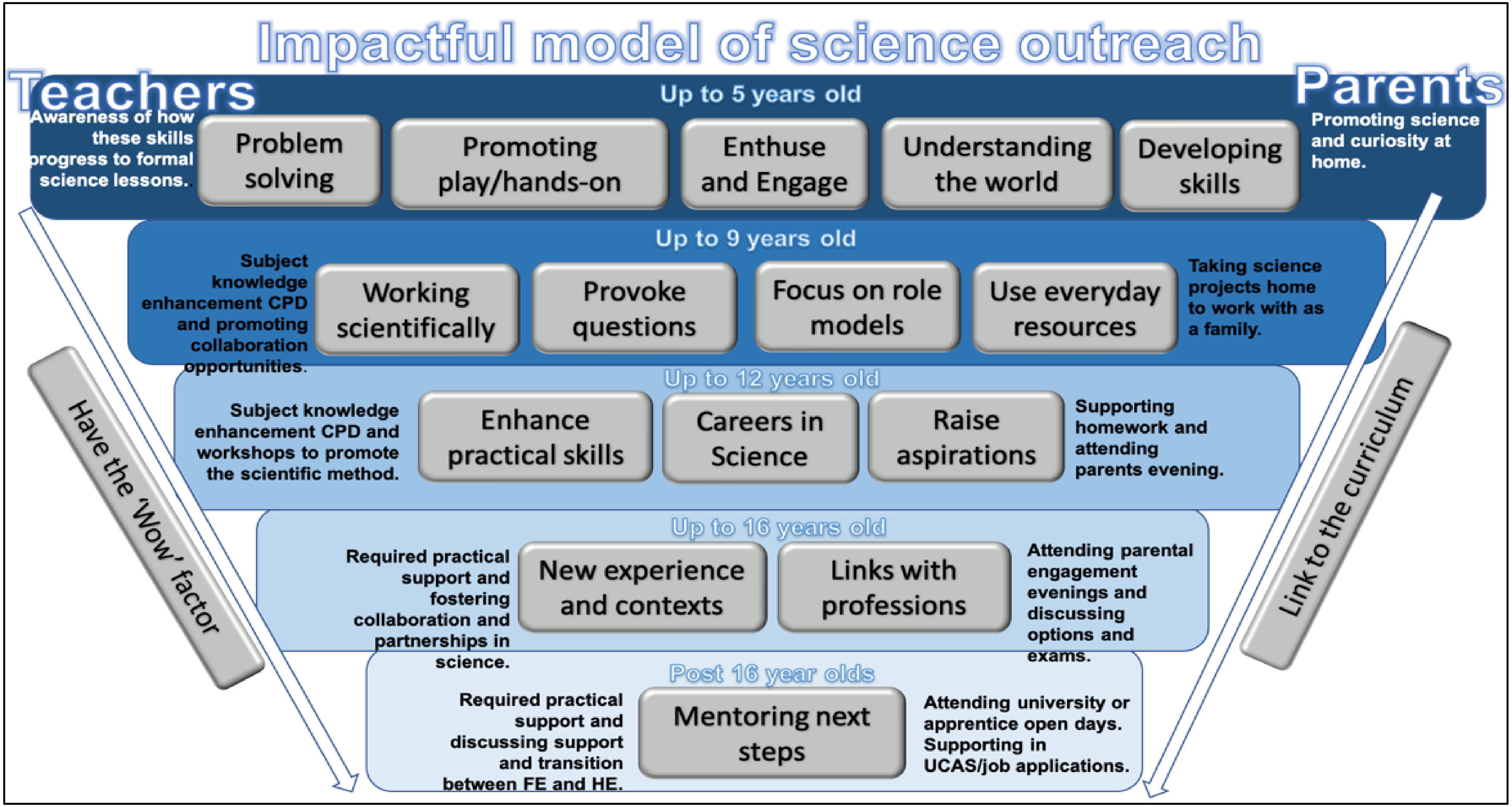


Figure 5-9 Presentation of the refined 'optimum model of science outreach' following participant input in wave 1

5.3.2 Wave 2 changes

After making the changes above and conducting another 'wave' of focus groups using the 'Wave 1 model' this was further refined. The changes during this phase were minor in comparison to the latter but are still explained and visualised (see Figure 5-10) below.

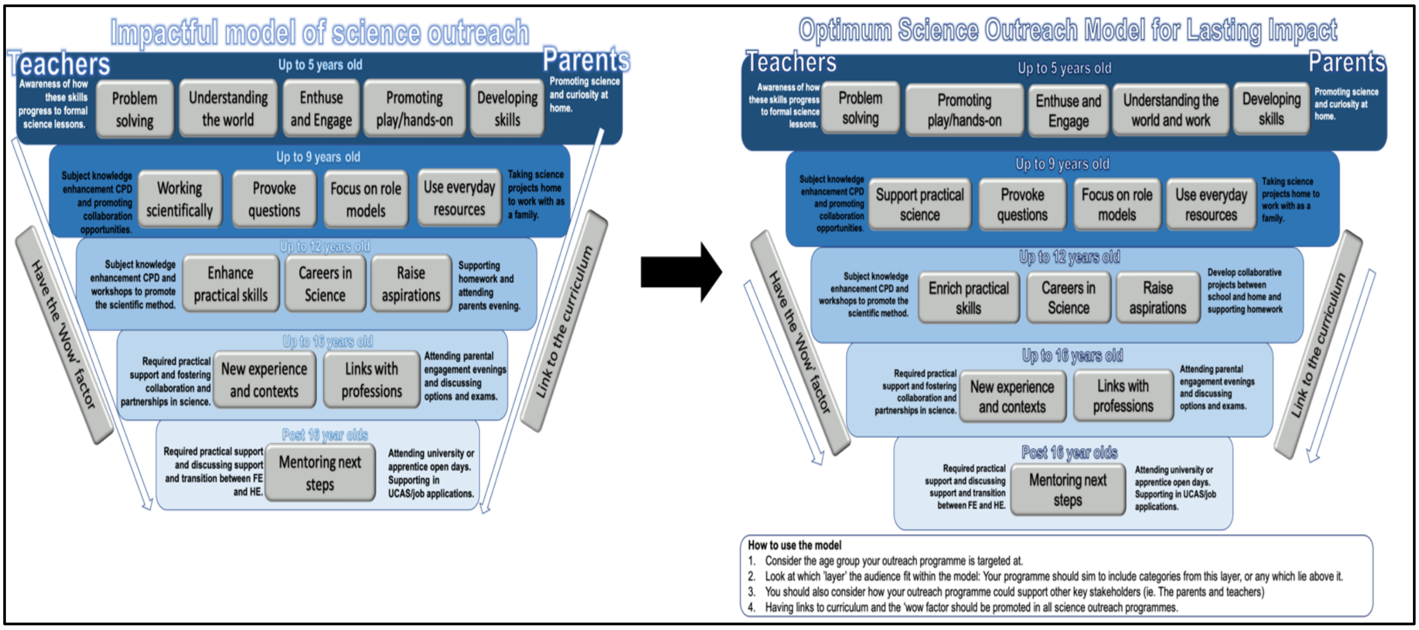


Figure 5-10 A visual representation of the changes to the model from wave 1 to wave 2

5.3.2.1 What teachers liked about the model

Participants within this wave of focus groups were also positive and were generally in agreement with the purpose and structure of the model "I like the stages", one participant stated. They were able to interpret how the categories in the different age groups supported the next as a participant expressed that "I like that it's like trying to go through the role models, the career and the context, they're all basically kind of the same thing." They also commented on the use of the term 'role models' for the younger audience; as a participant and a parent of a 9 year old they commented that "role models at the moment are generally dodgy reality TV stars so it's an area that needs focussing on". Whilst this is more of an opinion rather than a statement this is still insightful as Cridge and Cridge (2015) describe the influence role models may have on a young person and Jeffers et al (2004) also include 'engaged role models' as a common feature of many STEM outreach programmes. Thus, this is an important aspect to focus on when designing a science outreach programme and exemplifies why it should also be included in this model.

5.3.2.2 Suggested improvements to the model

Within the second wave there were less comments regarding changing aspects of the model. This is reassuring for the model refinement and the data collection process as it signifies that participants agree with the proposed model. The main refinements linked to the readability of the model and focusing on the possibly of science outreach programmes enhancing the home-school relationships. Participants discussed how "if there is a way outreach can somehow get parents on board, because that's our battle" and how that "getting something for the kids to take home, to promote discussions with parents" may help. Thus, this reaffirmed the importance of 'parents' being identified within the model and the idea of a 'take-away' activity to be included. The discussion regarding promoting careers at an earlier age remained; "I think the early capture, they're looking at careers in science but I think the more that you're giving them, different experiences and something to aspire to" and therefore, this reinforced the addition of careers to the earliest age range.

With regards to understanding how the model works there was still some slight confusion as participants were not sure about the cascade of the categories "I would like to see some of the Year 5s or 6s or Year 4s still doing these". However, after a quick explanation from the researcher this became clearer and participants described how "I think it does look logical, a logical progression of skills." Therefore, it was decided that the model should come with a short instruction box about how to 'use' the model as this would replicate the input from the researcher. The title of the model was also amended to solidify its main purpose, which aligns with the instructions presented. The participants also agreed that they preferred the funnel shaped model "I think I prefer that model than the circular one…it's more logical".

Lastly, there were just a few disagreements regarding the term 'working scientifically' as "it's just we use the term working scientifically all the way through….is the name for the practical skills" and this is also the phrase used within the Science National Curriculum (DfE, 2013). Therefore, this was changed as to avoid confusion. Another point of debate centred upon the category "enhance practical skills":

> Researcher: Is there any part of it that you think is not viable?
>
> Participant: I think maybe enhanced practical skills because if you're just hitting them with one lesson every now and again…it's not going to massively [improve their skill] (mumbles)
>
> *[Continued discussion about time to enhance practical skills]*
>
> Participant: I think sometimes that [outreach experience] has maybe boosted their practical skills

This shows that the participants recognised that there should be something linked to science practical skills but there wasn't a consensus of opinion regarding the use of the word 'enhance', due to the length of particular outreach programmes. Thus, the word was changed to 'enrich' as the definition of this in the Cambridge Dictionary (n.d.) is "to improve the quality of something by adding something else" which encompasses the purpose of outreach activities when working with learners who will already have some practical skills in science.

The final model based on Phase one and both waves of data collection in Phase two is presented in chapter 6.

5.4 CHAPTER SUMMARY

During Phase Two, collecting data from focus groups was the primary purpose of this stage of the research project to be able to refine the draft model of outreach activities/programmes presented in Chapter 4. However, this exercise presented a rich discussion regarding teachers' experiences and their ideas of engaging with science outreach programmes. The principles of constructivist GT were then used to present substantive theories which emerged from the data. The substantive theories focused on the importance of key stakeholders being included in the design and aims of the programme and thus supports the primary purpose of this phase of the research. These theories could be linked to findings in other literature and wider fields and confirmed how outreach programmes that understand the needs of their stakeholders, can be more effective (Holmes et al 2014; Joshi et al, 2013; Lhussier et al, 2015). The emergent theories supported this notion and also the idea that a holistic and collaborative approach from those who design the programmes, can further contribute to their success (Asmus and Schroeder, 2016; Giboney Wall and Musetti, 2018). Theory 2 focused on the purposeful design to be able to meet the desired outcomes of the programme; this was evidenced retrospectively in Brown (2018). It is also supported via the generation and refinement of the 'optimum model of science outreach' within this phase of data collection and is presented in its final form in the next chapter.

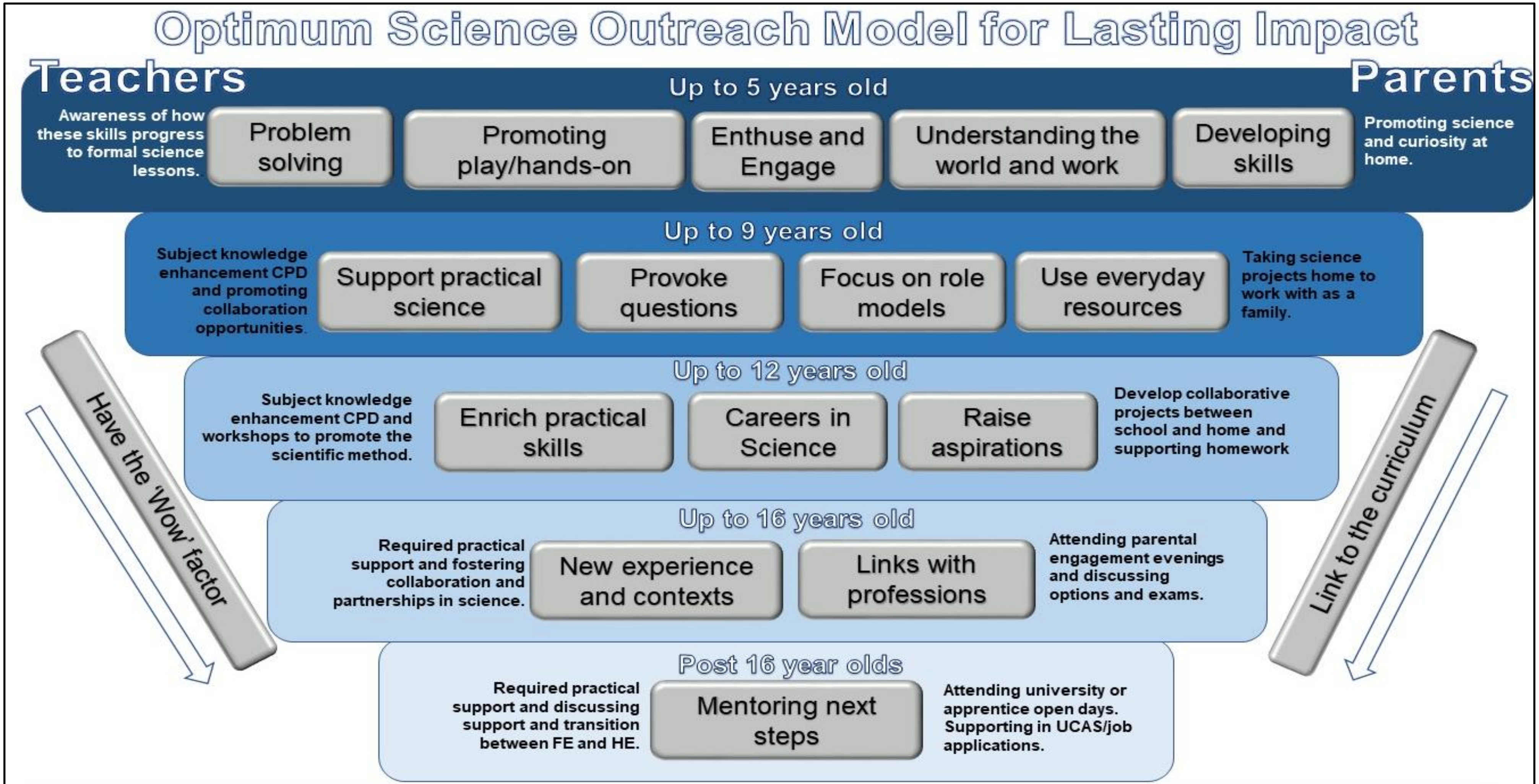
CHAPTER 6: PRESENTATION OF THE FINAL MODELS

Following the data collected in Phase Two, which builds upon the findings of Phase One of the research study, this chapter presents the concluding theoretical model of the 'optimum science outreach model for lasting impact' and a rationale of how it intends to improve outreach provision. The model has been designed using data collected in this research study and participants' perceptions and comments have been used to inform the design of the model. As this critical engagement from teachers across the 5-19 age range come from different groups of teachers, the primary data in this chapter is presented as a collective voice and therefore direct quotes are not linked to an individual participant (Cohen et al, 2018). In addition to the original data, each stage of this study has been underpinned in the context of wider literature which enabled discussions regarding the utility of the model to be placed in a larger, international context. Thus, the model presented can be used to support the design of science outreach programmes to make it more impactful for a national and an international audience.

This chapter also presents a version of the model that aims to engage learners from lower-socioeconomic backgrounds as it was explained in section 2.2 that home-life of an individual can impact on their future choices (Gorard and See, 2009; See et al, 2012; Griffin and Hu, 2015; Bellibas, 2016; Brennan et al, 2018) and this idea is featured within the theoretical ideas which underpins this study (Schoon et al, 2007). Thus, the additional model still encompasses the ideas of the 'optimum science outreach model for lasting impact' but is presented as the 'optimum science outreach model for learners from a lower socio-economic background'. This is presented in section 6.2.

6.1 THE OPTIMUM SCIENCE OUTREACH MODEL FOR LASTING IMPACT

Following participant feedback regarding the model in Section 5.3.2, revisions were made to a draft version of the 'optimum science outreach model for lasting impact' and the final version is presented in Figure 6-1. Teachers from across all educational levels (5-19 age range) have supported the model's design and the rationale for each aspect has been explained throughout and summarised below. The model aims to have a more 'lasting impact' by drawing existing research that endorses the creation of the model from primary data collected as part of this research study.



How to use the model

1. Consider the age group your outreach programme is targeted at.
2. Look at which 'layer' the audience fit within the model: Your programme should aim to include categories from this layer, or any which lie above it.
3. You should also consider how your outreach programme could support other key stakeholders (ie. The parents and teachers)
4. Having links to curriculum and the 'wow factor should be promoted in all science outreach programmes.

Figure 6-1 The Optimum Science Outreach Model for Lasting Impact: Final Version

6.1.1 The Aims and Intent of the Optimum Science Outreach Model for Lasting Impact.

The aims and intent of the model generated during this research study centres around encouraging those who design and deliver the programme to understand who should be included within these programmes and what content should be covered. By outreach providers utilising the model in the design of their activities, it aims to make these more impactful. Van der Hurk et al. (2019) explain how outreach events should often have a clear purpose in promoting science agendas and describe how many STEM programmes aim to increase non-compulsory engagement within a field. However, 538 studies were systematically reviewed, and this provided no consensus as to whether they were effective or not (Van den Hurk et al., 2019).

Banerjee (2017) also states that even with sustained engagement with a STEM outreach programme, this did not assist with widening participation (WP) or increasing those continuing to pursue a STEM subject. However, there are many singular studies which do find positives to be gained from participating in outreach activities (Dyer, Venton and Maeng, 2018; Gall et al., 2020). For example, Landry et al. (2019) found that teachers who were present during outreach events stated that they felt their children's involvement in a computer science outreach programme did improve their attitudes. In another study, Vennix, den Brok and Taconis (2018) collated 729 questionnaires from high school students in the USA and Netherlands and concluded that outreach learning environments provide opportunities to increase students' motivation and attitudes in STEM. Therefore, whilst there is no consensus, these studies highlight how these activities do have the potential to have positive impacts(s) on the learners.

Attitudes and interests towards a topic are discussed within different motivational frameworks (Eccles, 1982; Deci and Ryan, 2000; Gutman and Schoon, 2012) as this can influence a person's self-efficacy, which is their belief in their capacity to achieve in science. Whilst the above examples focus on how it could impact the learners; there are also examples of a positive effect upon the teachers (Van den Hurk et al., 2019). Velthius, Fisser and Pieter (2015) found that improving primary science provisions could be achieved through increasing teacher's self-efficacy in science. It was concluded that by including teachers within 'teacher design teams', that this had a positive impact on increasing teacher's self-efficacy in science and therefore, was a useful professional development endeavour (Velthius et al., 2015).

The development of this model also aims to increase an individual's science capital. It is explained by Godec, King and Archer (2017, p.7) that "science capital incorporates an individual's science-related resources and their habitus, or attitudes and way of thinking." It is anticipated therefore, that participation in these informal science outreach programmes that have a purposeful design with a focus on hands-on activities and role models, may further equip learners with science-focused resources and habitus. For example, DeWitt and Archer (2017) discover how informal science learning experiences can offer unique and memorable opportunities to increase learner's engagement in science. Thus, increasing the frequency of an individual's participation in science can increase their science capital, which has been found to increase the likelihood of an individual choosing to study science in the future. Science capital is developed throughout a learner's educational experiences, however, their habitus regarding science can influenced by home, school and wider communities (Godec, King and Archer, 2017). Therefore, how the design of the model may further influence the growth of science capital is further explained in sections 6.1.2.1, 6.1.2.2 and 6.2.1 within the specific context of each stakeholder.

A further aim of utilising this model is to make science outreach more accessible and sustainable for a wider audience so that these outreach programmes can be more impactful in terms of promoting science as a viable career. These features are discussed in detail in section 6.1.2 and exemplified by Dyer, Venton and Maeng (2018) who discuss their US-based chemistry outreach programme which was aimed at younger learners to encourage further engagement in science. They recognised that the impact of these programmes would be minimal due to logistical issues in the delivery of the programme. Therefore, they organised a one-day professional development (PD) opportunity for teachers to attend to learn how to deliver these inquiry-based sessions. It meant that instead of a handful of schools being able to engage with the programme 52 teachers across six school districts delivered at least one of the activities. Thus, the reach of the outreach programme was extended whilst still being manageable to co-ordinate. Participants in Phase Two of the research study, reflect on a similar experience by stating; "they gave us a box that we could bring into school" which meant that from the outreach experience they had been involved with, resources were given to continue the project and extend this experience in the school setting. Whilst this is a good example of making these experiences sustainable, James et al. (2006) discuss how it takes time to develop a quality partnership and that there must be shared common goals for it to be successful. Therefore, this model aims to support this approach, by engaging learners, children and parents from across all the formal education age groups.

When considering how to organise the content for the learners as part of the model, this was derived from primary data in Phase One (see Chapter 4) and refined by focus group (FG) data in Phase Two (see Chapter 5). The construction of this model was also informed by the English National Curriculum (DfE, 2013), which aligns with the formal education system the participants within this sample are familiar with. When considering a curriculum and its purposeful design, Luke, Woods and Weir (2012) found that the defining educational goals shift towards economic and technological demands of a country. Larkin (2016) adds that the history of education reform points to a need to understand the local contextual factors that support, hinder, and sustain efforts to improve learning in schools. Whilst these ideas relate to designing a curriculum; they are still relevant when considering the 'framework' that is presented within the model. Science outreach is intended as an informal learning opportunity, and therefore, it was not intended that the categories within the model would be prescriptive, but support Foucault's (1972) theories around mapping knowledge and understanding that curriculum content is linked to the context and time in which it is being delivered. Thus, this model is a "grid of specification" (Luke et al., 2012 p. 6) that is designed to be used in a flexible manner, but support Dewey's (1915) analogy of the curriculum as a journey.

Although the Science National Curriculum (DfE, 2013) was chosen due to the participant sample and the researcher having personal experience of this, reviewing STEM outreach programmes globally (see section 2.4) also informed the content for the model. For example, the framework devised by Jeffers et al. (2004, p.95) demonstrated that many of the categories within this optimum model (**Error! Reference source not found.**) can be translated i nternationally as outreach programmes tend to follow similar approaches. These consisted of hands-on activities, inquiry-based learning, curriculum supplements, engaged role models, teacher involvement and focusing on younger students, and many of these features can be seen in Figure 6-1.

6.1.2 How the design supports the aims of the model

This section considers how the design of the model presented in Figure 6-1 supported the overarching aims discussed in section 6.1.1. These align with many aims of WP outreach programmes which aim to promote and encourage the school-aged generation to persist within a particular STEM field (Alexander et al., 2018). Van den Hurk et al. (2019, p.155) use their systematic review of different STEM interventions to present their own theoretical framework entitled "Model for academic choices and persistence in STEM education" and the six categories included within this are social context, school context, social environment, malleable student characteristics, non-malleable student characteristics and educational outcomes. The model and emergent theories presented in Chapter 5 created via this research process, supports the model of Van den Hurk et al. (2019) as participants' responses within this study were often shaped by social and school contexts, such as "if the Head (teacher) doesn't have it [outreach] as a priority it's hard as a teacher" and "we've got a lot of pupils who don't like going out of their comfort zone." Being able to draw upon other researchers' frameworks, along with the theoretical underpinning of Gutman and Schoon's (2012) model, provides further confidence in the design of the original model generated in this Chapter.

It is suggested by Ralston, Hieb and Rivoli (2013) that to address this 'leaky pipeline' in STEM, which is described by Van den Hurk et al. (2019) as continual drop out of STEM education, then outreach programmes should begin at a lower school age (in this case, elementary/6-11 year olds). Kang et al. (2019) suggest that if primary students' interest regarding science can be nurtured until they transition into secondary education, then this may further encourage individuals to persist in science. This is reflective of Gore et al.'s (2018) findings as one of the predictors of attending medical school aligned with having ideas about being a doctor at a younger age (or not). Therefore, the findings from the participants within this research project, the examples provided (Ralston et al., 2013; Kang et al., 2019; Gore et al., 2018) and a plethora of other research (for example, DeWitt, Archer, & Osborne, 2014; Schoon, 2001; Tai et al.., 2006) further supports the notion that science outreach initiatives should start at a younger age for impact on career choices. Participants from the focus groups agree as they suggest that:

> I think for the youngest ones, you need to enthuse and engage. I think to start them young 'cos you have to have them and if you haven't got it if you lose them too early, you kind of, you've got a hard battle then. (FG 1)

Thus, the framework within the model in Figure 6-1 has its first category for learners 'up to 5 years old'.

Gall et al. (2020) discuss the different impact types of outreach events may have on student attitudes' towards science, based upon the nature of the event. Those events which were inbound whereby programmes were delivered within the school were able to target groups of underrepresented students more effectively, but the change in attitudes experienced was less impactful in these settings. An out-bound experience, such as a school trip did have a significantly bigger impact on the learners, but these events are somewhat difficult to organise at times (Gall et al., 2020). This was highlighted by the participants within Phase Two: "I enjoy doing that [going on a trip] more than I do in a classroom, but I can't give it that much time". However, both settings have positive impacts with regards to improving attitudes of learners and reaching underrepresented groups in STEM (Gall et al., 2020), so are equally as valid in a science outreach programme. Landry et al. (2019) agree as they discuss how there needs to be a balance between the novelty of both the setting and the materials within a programme. This is of particular importance if it is a 'stand-alone' event as learners may focus on the new place as opposed to the materials which were covered. In addition to this, Vennix, Den Brok and Taconis (2017) discuss how if these discrete/shorter activities were more 'lecture' based' and less hands-on, the students within their research study indicated a lower level of autonomy. Hence, the characteristics of the programme itself are crucial to its success in being able to impact upon attitudes and motivations towards STEM subjects. Ideas around what these characteristics are and where outreach activities may take place are supported in the design on the model (see Figure 6-1) as the features of the model are not bound to a particular location.

6.1.2.1 For the Learners

Whilst previous discussion focuses on how the model can be used to further support learners in science learning, the framework also aims to advise individuals about careers within science. This ranges from 'understanding work' in the earlier years, 'focusing on role models' and 'careers in science' in the middle years and 'links with professionals' and 'monitoring next steps' in the older years. Collinson (2014) discusses how there is now a more explicit focus on providing careers knowledge within schools for example, in England, this has been a focused on Ofsted's agenda since 2013. Ofsted (2013), who inspect state schools in England and Wales, find that teachers, parents and other professionals are the key influencers upon children's ideas regarding careers. As Kang et al. (2019) suggest, if individuals can 'see' and 'relate' to someone (or something) that could spark further interest.

Therefore, including these wider stakeholders and advocating careers within the design of the model this may contribute to building science capital and generally improve career guidance for young people. Ofsted (2018) have taken steps to provide more guidance on how schools provide this type of education by advocating the Gatsby benchmarks (Gatsby

Foundation, 2013). Thus far, findings indicate that making career guidance more personable, linking it to the curriculum and providing more opportunities to encounter higher education and industry can have a positive impact on students' career readiness and GCSE attainment (Hanson et al, 2021). These ideas are further supported within the design of the proposed model whereby aspects such as 'focusing on role models' and 'using everyday resources' are included. These categories also support some of the key dimensions of being able to increase an individual's science capital (Godec, King and Archer, 2017). For example, the learner may further recognise the transferability of science by meeting more people in science related roles and in turn broaden their view of where science could lead especially in the context of careers (Archer et al, 2013; Archer et al, 2020).

Analysis of the quantitative data in section 4.2.1 revealed that the participants within the data set of this research study thought that that science outreach events were of equal importance to both genders. However, interests in the specific subjects are often indicative are specific gender interests, i.e. girls often favour biology and boys the physical sciences (Kang et al., 2019). The gap between gender preferences increases with age until many girls gradually lose interest in aspects of STEM by the later years (Blickenstaff, 2005). Thus, ensuring all disciplines of science are inclusive for any gender is important as this could also impact upon motivation within the subject (Kang et al., 2019). For example, boys tend to prefer chemistry and physics and the associated practical activities compared to girls. In a mixed classroom setting, boys become a little boisterous and girls become less engaged in lessons. Kang et al. (2019) describe how girls like being hands-on, so promoting experiences where they also get to be more involved in different settings can assist with furthering girls' interests in the physical sciences. Referring to the model depicted in Figure 6-1 these opportunities for all learners are presented at the youngest age category by 'promoting play/hands-on' and moving to 'enhancing practical skills' as the learners get older.

Vennix et al. (2018) discuss how science outreach experiences should bring something to an audience, which is beyond their usual experience. Participants from Phase Two agreed as they discussed an outreach event which provided a new opportunity. A focus group described how "I would love them to be able to see it in school, but we haven't got it"; outreach events can provide this platform. Kang et al. (2019, p.97) suggest in their findings "that in order to make science subjects appealing to many students, it is important to highlight the impact of science on their life." This was an aspect that was also discussed in both Phase One as the theme "outreach work shows how science is applied in a real-life context" was presented and in Phase Two as the category 'changing minds' , discussed in Memo 1. Thus, the category of 'understanding the world' is introduced with the earliest age group and is further supported by the 'use of everyday resources' and introducing 'new experiences and contexts' for the older students. This idea of contextualising science also supports the previous discussion about the importance of a 'focus on role models' and 'careers in science.' Aslam, Adefila and Bagiya (2018, p.58) discuss how those who deliver these programmes often become the "face of STEM" to learners as they can provide "real-life applications" of the knowledge they teach and promote up and coming careers.

6.1.2.2 For the teachers

Archer et al (2020) describe how young learner's choices regarding science are often influenced by a system of gatekeeping within schools, the science courses they are advised to take at high school exam level and the attitudes and behaviours of teachers towards science. They advocate how science experiences at school, such as opportunities or even as systematic as teacher retention and quality, can impact upon an individual's science capital. Thus, Aslam, Adefila and Bagiya (2018) explore teachers' understanding of their role as primary facilitators for students engaging with these programmes and find that in doing so, teachers can renew their STEM professional identity. Teachers are also able to spark interest in science as, particularly in primary school, they have roles as both instructor and role model (Kang et al., 2019). For children, they may be the first 'professional' adult that they see, and if teacher's own bias is demonstrated within the classroom, then this may have an impact on the children they teach and their own motivations. Therefore, supporting teachers is included within the proposed model due to the integral motivational role model they can have for children and their capacity to build an individual's science capital, which can therefore, influence the children's future career choices (Archer et al, 2020; Deci and Ryan, 2000; Eccles, 1993; Gutman and Schoon, 2012).

There is a renewed perspective of the importance of teachers in government science documents; for example, the Science Advisory Committee (2011) in New Zealand discuss how the teacher's ability to access contemporary contexts will provide mutually beneficial experiences for both students and teachers (Cripps-Clark, Tyler and Symington, 2014). One of these contemporary contexts could see teachers collaborating with scientists to provide discussions about up-to-date science issues, but these will be made further accessible to the learners, as teachers can place them into a relatable context (Cripps et al., 2014). These types of collaborations can be mutually beneficial for both the teacher and the scientists to improve understanding and science instruction (Szteinberg et al., 2014). This is further exemplified by a

Phase Two participant who recalled how attending these events "allows us to see there is a gap there in those skills" for their learners. Thus, the model includes some ideas of how the facilitators of outreach programmes could further support teachers which may assist in promoting a positive relationship between schools and those who design and deliver outreach activities in science.

The model in this study identifies that science outreach is a key opportunity for teachers to encounter Professional Development (PD) opportunities. Due to the busy work schedule of teachers across all educational levels, there is often limited time to engage in these activities (Gatt and Costa, 2009). PD is important for teachers as Murcia and Pepper (2018) found that teachers who attended PD sessions felt more confident in their own knowledge and understanding, and thus how they would plan science activities in their own classrooms. The PD sessions in Murcia and Pepper's (2018) study were developed through a collaborative approach between STEM industries and teachers, where teachers could assist with the development of new resources that would be used within the classroom. However, there are no strict guidelines as to what should be included as part of a PD programme; for example, Fakayode et al. (2014) discuss how their geoscience PD programme utilised the experiences of first-year university students to reflect on the challenges that they encountered in their science learning that had allowed them to access their degree programme. The workshops provided a platform for students to discuss this with the teachers so that the teachers could resolve these challenges and create a more positive experience for the children they taught. Thus, PD is not prescriptive, and that is why the 'teachers' section on the model in Figure 6-1 indicates suggestions of what topics could be covered with teachers but not how this would be delivered.

Sansone (2018) looks at developing 'communities of practice' as an approach to improve teaching and learning for science students in middle schools. This approach builds upon Wengner's (2010) social learning process, which is centred on culturally situated knowledge and practices. In a classroom, rather than having a transfer of knowledge between teacher and student, this aligns more with ideas of being an 'apprentice' with a view to becoming a 'master'. In science teaching and learning, this can help to develop a sense of 'scientific identity' (Sansone, 2018 p. 18). Whilst these ideas focus upon students, communities of practices are flexible and can be fostered at any academic level or in any field (Lave and Wenger, 1991). Gatt and Costa (2009) also recognise the benefits of these opportunities but suggest teachers lack time to participate in these communities of practice. Hence, science outreach can provide a platform to develop communities of practice whereby teachers can support other teachers to develop the science teacher's identity. Participants from Phase Two present similar ideas "from a teacher's point of view, it's been really informative for us because it's about us being up to date and up to speed and being able to advise the student in the right way". Mintzes et al. (2013) found that teachers who worked as part of a Professional Learning Community (PLC) increased their self-efficacy in science, and they felt empowered with their science teaching. Similarly, Murica and Pepper (2018) also mention how teachers within their sample felt empowered after the collaborative nature of their PD sessions. Thus, it is clear from the evidence from this study and wider literature that fostering opportunities to allow teachers to collaborate and empower each other will have an impact on their future practice in their science classrooms.

6.1.2.3 For the Parents

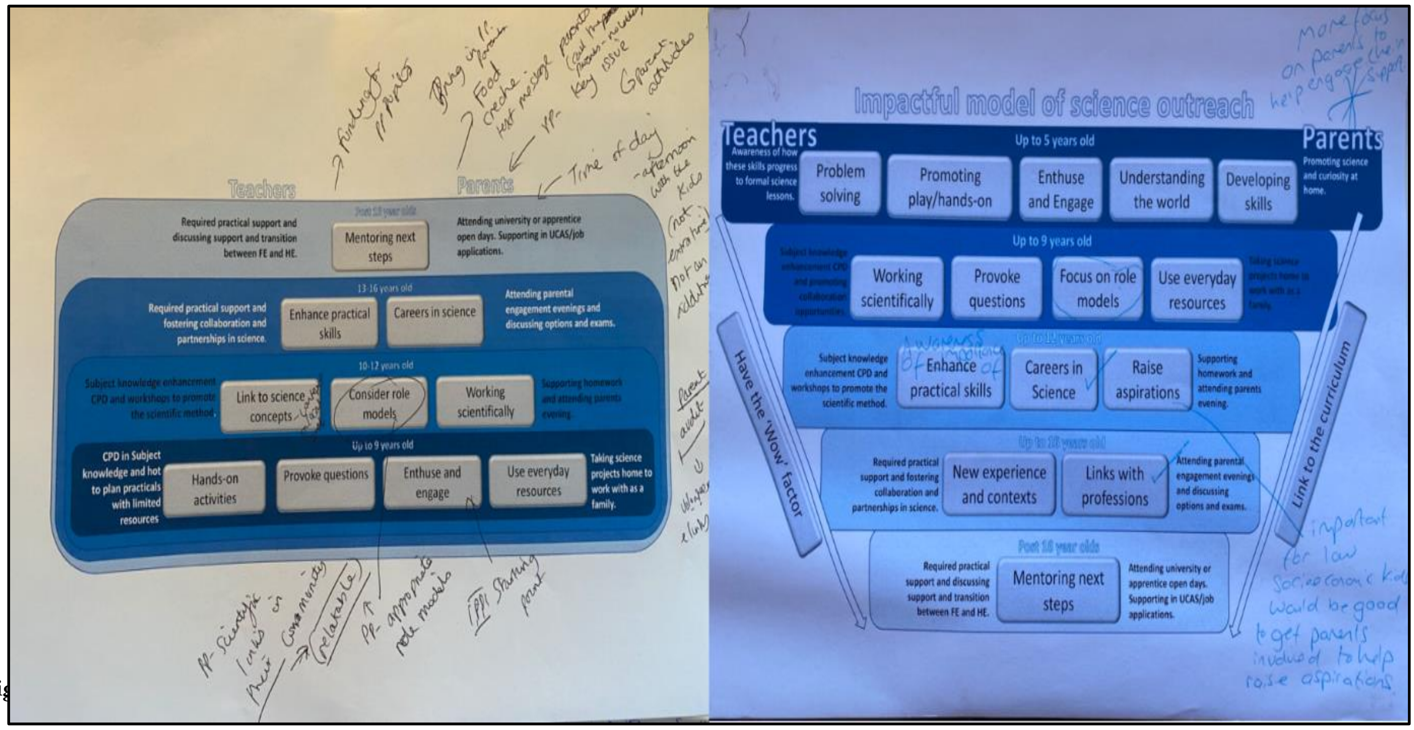
Parents are not mentioned as key stakeholders in Chapter 5 of this thesis, but their importance is highlighted in Memo 2 and Memo 6. Given their input; therefore, parents (along with teachers) should be visible stakeholders within the design of the 'optimum science outreach model for lasting impact' (see Figure 6-1).

The inclusion of parents can take many forms, such as those mentioned in the paragraph above. However, involving parents might also be to inform and further educate the parents themselves. For example, Colgan's (2016) STEM programme encompassed an information platform regarding a mathematics outreach programme that had specific sections and resources for parents. These resources would allow them to refresh their own knowledge and learn about new careers so that parents could further support and encourage their own child. Although the proposed model in Figure 6-1 depicts activities that would be suitable for parental involvement with outreach programmes, these again are suggestions, which align with the specific age range. Including parents, in any context, is important just to increase engagement. Avvisati et al. (2014) support this as they studied long-term parent-school programmes in French Middles Schools (for learners aged 11-15). Findings indicated that at the end of the academic year, parents had increased their engagement with schools. Although this did not lead to improved academic scores for their children, there was a noticeable improvement in attitudes and behaviours. They concluded that "increased parental involvement may represent an efficient alternative way to foster the acquisition of relevant attitudes" (Avvisati et al., 2014 p. 59). Therefore, having parents as visible stakeholder's within the proposed model aims to remind those who design these programmes that benefits will be much more sustained if their activities encompass the children's parents.

6.2 FOCUSING ON A PARTICULAR GROUP OF LEARNERS

As part of the focus group in Phase Two (see Chapter 5) participants were specifically asked to reflect on disadvantaged learners who come to a lower SES as this particular group of learners aligns with the theoretical discussions presented as part of this research. Whilst STEM outreach initiatives have generally focused on improving attitudes towards science for all; there is another drive to further diversify the STEM workforce (Gall et al., 2020). However, Smith (2008) describes how access to Higher Education is becoming increasingly marginalised for those demographics with a lower socio-economic status (SES), especially with regards to being able to access their college choice. Van den Hurk et al. (2019, p.154) agree as they state that "it is found that students from minority backgrounds and/or with low socioeconomic status (SES) are less likely to pursue a career in STEM education." For example, Archer et al (2020) identify how the most socially-disadvantaged students are less likely to pick the more academic science routes in schools in England, which may have an impact on whether learner's identify as being 'science-y' and thus foster a lower science capital.

Additionally, learners of a higher SES status with parents more highly educated are more likely to choose STEM subjects and persist for longer within the field. This links to Gutman and



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Schoon's (2012) theoretical model of 'developmental-contextual model of career development'; they suggest that along with 'academic performance', the influence of 'parental SES' begins at birth and continues throughout an individual's schooling experience until they can make their own choices on what to do. These principles are also embedded within the key dimensions of building science capital. For example, a family's level of skill and knowledge regarding science and whether science is talked about or participated in outside of school (Godec, King and Archer, 2017) can influence a child's perspective. These aspects are underpinned by the findings from the ASIPRES project as it was determined that families exert a considerable influence on students' aspirations as parents hold a relatively narrow view of where science can lead (Archer et al, 2013). Therefore, by designing science outreach to be more impactful it could enhance the science knowledge and experience of both the learners and their families. This in turn, could impact on an individual's mind-set towards science, which Archer et al (2020) highlight as a key strategy to further build science capital with the aim that a learner will feel that they are more 'science-y'.

Thus, participants specifically considered which aspects of the draft model would be of importance for children who are from a disadvantaged background as exemplified in Figure 6-2. When considering responses from the questionnaire regarding science outreach and those in receipt of the pupil premium in Phase One (see Chapter 4) part of the participants discussion centred around how outreach events may have the potential to provide experiences for children who might be missing out which aligns with Morgan et al's (2016) concept of an 'opportunity gap'. This idea of a child missing out on experiences compared to their more affluent peers is further captured in a participant's response during Phase Two of the study, who suggested that "I don't know about adding anything, but I would say there might be a greater emphasis on getting them out the school…because they may be less likely to get those experiences." These gaps could arise due to a range of factors. For example, parents determine where the child resides and therefore, the child will have access to particular resources and settings within their local surroundings/community. Türk (2019) defines this as the residential location-equality of opportunity (EOp), which reflects the aspect of where you live, making you 'lucky' or 'unlucky' (Ofsted, 2013b). This is further captured in a longitudinal study by The Social Mobility Commission (2020) who found that individuals who were disadvantaged, but also from an area of low social mobility, were likely to earn half compared to their less affluent counterpart from an area of higher social mobility. Türk (2019) also found that the educational level of parents is highly influential for the academic attainment of Italian students and links to ideas presented by

Tobin (2004) and Fleer and Rillero (2008) in Chapter 2.2 that parental education may impact on their child's attainment also. Thus, family life can have an impact on many aspects of an individual child's beliefs and motivations (Wang and Degol, 2013). Therefore, considering this group of learners from a lower SES in particular, the 'parents' aspect of the model was featured highly here with the focus groups and is further explained in Section 6.1.2.3.

6.2.1 Focus on parents

Haut, See and Gorard (2015) confirm in their systematic review, that parental involvement does link to attainment in schools. This may have an impact on progression into university courses; Banerjee (2018) also describes this as a potential barrier for young people to progress into HEIs. When focussing on science, it was found that in many developed countries there has been little improvement in science attainment and that parent's attitudes towards the value of science can influence their child's achievement within the subject (Heddy and Sinatra, 2017; Perera, 2014). In the USA, George W. Bush (the president at the time) signed the 'No Child Left behind Policy' (US Department of Education, 2004) which aimed to reduce the academic gap between disadvantaged students and their more affluent counterparts. Part of this policy centred on increasing parental involvement. McMahon (2018) suggests that 'parental involvement' was loosely interpreted by many states in the USA, which meant that this important aspect did not quite have the desired effects on students. The idea was that making parents feel empowered by assisting their child's school and teachers, can have a positive impact on their child's academic performance. Whilst the proposed model presented in Figure 6-1 supports these ideas, the focus on parents when working with disadvantaged students of a lower SES is particularly profound, mostly for their potential outlined above.

Although this focus of parents was advocated by participants in every focus group (*n*=4), they were very pragmatic in their responses about how easy (or not) this level of engagement is to achieve. Even as parents' themselves, they considered how if their child's school offered support that "I wouldn't go. Telling me how to help them do their homework and I think 'no.'" Thus, if this is the attitude parents who are also teachers have, it just highlights how difficult this task can be. Wooden and Anderson (2012) found that even if parents show enthusiasm towards these engagement events, getting even a small percentage of these parents to attend them could be a challenge. Participants from Phase Two agreed how this can logistically be difficult to achieve but that it can be worthwhile, for example:

> Look how much some of the parents actually engaged in the open evening, with some of the activities that they were doing with the kids. They loved it and it got the kids talking, and you saw kids talking to their parents as you walked away. So you know it will have an impact.

This response from this participant further highlights how science outreach activities that include parents within their design, can further increase an individual's science capital. For example, Bell (2020) carried out their own 'family science' initiative and feedback from parents indicated that following on from the activities that were delivered as part of this programme, parents were now saying they were finding their own extra experiments to do as well with their child at home. Similarly, this approach to involve parents is advocated within the design of this optimum model as participants within the FGs discussed the important of this. Edmonds, Lewis and Fogg-Rogers (2018) further suggest that it is important to involve mothers, to promote more positive attitudes towards science as mothers are one of the most influential figures in a child's life, especially for their daughters.

Additionally, fostering this relationship between a parent and their child can be beneficial for wider stakeholders as Alldred, Fox and Kupla (2016) found that increasing these interactions can provide a more cohesive experience for a child's learning. In their study regarding parents engaging with sex and relationship education, they noted how these collaborative experiences also allowed the parents to adapt their own views (Alldred et al., 2016); which supports Smith's (2008) notion that to make this relationship more effective, parents must experience a paradigm shift.

In addition to fostering these home-school relationships, the Social Mobility Commission (2017) also advocate how this parental engagement is of increasing importance as a learner progresses through the educational levels. This is because there are higher expectations for the learner to be more independent and in turn, parents of a lower SES are less likely to be able to access this complex curriculum. Therefore, the streamlined model (see Figure 6-3) encourages parents to support their child's science journey at all educational stages and refresh their own scientific knowledge in doing so.

Participants in the study recalled how "if we didn't have parental support we'd struggle" but understand that there are now lots of "pressures on parents" as "it's really difficult for lots of parents now isn't it, 'cos they're working till late at night." They discussed how some strategies had been successful for them, such as "food is always a good one…they've got younger siblings they can't leave at home and stuff…if you've got prefects and things like that they can look after the younger ones…anything like that will make a massive difference." Therefore, both schools and outreach providers should plan how they are going to work to engage parents as this aspect is deemed to be important due to the significant impact it has on children from a lower SES, across all educational levels (González and Jackson, 2013; Social Mobility Commission, 2017).

The relationships between parents and schools do vary across the different educational settings as participants described the relationship "difference parents have with their primary school and the relationship the same parents have with their secondary school, and it's never the same". At younger education stages, parents often take their child to school and teachers are "welcoming their kids into primary school" meaning that the "parents ultimately feel comfortable" with the teachers. As this is often not the routine in a high school setting, this communication is more strained. Focus group participants from a secondary school found that it "makes a difference, not sending letters, cos they [parents] don't get them. Text messaging makes a huge difference". González and Jackson (2013) discuss how if the increasing parental engagement can have a positive impact on students; this should be a focus for schools. Participants recall how spending extra time to engage the parents did work as they shared their reflections on a parental night and proposed how they thought "if we hadn't made that personal kind of conversation, connection, they [the parents] probably wouldn't have turned up". Thus, considering these suggestions to foster home-school relationships, this relationship could be enhanced by outreach programmes in a similar way. In addition, by reaching out to parents with science outreach activities, this could result in sustained impact, even from a stand-alone event.

6.2.2 Focus on role models, careers and raising aspirations

Participants discussed how, when focusing on outreach programmes that work with under-represented groups of learners in science, they should focus on 'changing minds' which was a category generated in Phase Two. Memo 1 depicted how this involved being able to resolve stereotypes about scientists and careers, in the hope of 'changing minds'. Thus, participants depicted how "raising aspirations and then linking it with professions" is important for this group of learners but making sure that there is a "wide variety" of careers discussed which learners relate to. This could be achieved "if you can link it to role models…if there are people, in certain careers and who have come from a similar background" and in turn, "I think the role model thing possibly could have a greater emphasis in terms of raising aspirations". Egalite and Kisida (2018) support this notion, as they paired a student with a teacher who had a similar demographic characteristic. They found an increase in the student's positive perceptions and attitudes in school; this was particularly true when genders and/or ethnic minorities were matched. Using role models as an intervention was also found by Haut, See, Gorard and Torgeson (2014) to be effective, especially for students from disadvantaged backgrounds.

Considering who these role models could be, Van Der Hurk et al. (2019) discuss how the lack of a relatable role model can be a deterrent for many of the learners and whilst parents can promote STEM education, they may also discourage them. Within this study, participants provided possible solutions for these concerns as they suggest that that "linking it [outreach] with parents' jobs and careers" can be effective as "getting the correct role model is important as well, so getting role models who've come from similar sorts of backgrounds from what they've[the learners] come from". Using parents from a similar demographic makes them relatable and creates roles models whom these groups of learners can "associate with." Thus, mentors or role models can take many forms such as, the parents, the teacher or those who facilitate these outreach programmes as they may also represent marginalised groups in STEM. This is important, as Banerjee (2018) concludes, that children who are unsure of possible progression routes are less likely to go to university. Parents who have not been to university would not be able to inform their child effectively having not experienced this themselves; thus, roles models and facilitators may be able to provide this information. Therefore, within the model, the categories that link to role models and careers have been highlighted as the most important to be able to raise the aspirations of disadvantaged learners and utilise suitable role models to provide this support. These categories included in the model would also align with the Gatsby (2013) Benchmark recommendation for 'Good Career Guidance' which have now been directed by the government to be used within schools in the UK (RSC, n.d.a)

The ideas presented in this section align with many of the motivational theories explored in section 2.1, and they also come under other guises within the theoretical model which underpins this study 'perceived ability', 'uncertain motivations' and "school motivation" (Gutman and School, 2012). Having increased motivation may mean that these individuals are more engaged with science, in and out of the classroom, which can have a positive impact overall. Ralston, Hieb and Rivoli (2013) found that children who continue science interests outside of the classroom, such as a hobby, increase their self-efficacy which Van den Hurk et al. (2019) found important when it comes to future career choices. Thus, Griffin and Hu (2015, p.103) state that "addressing of low self-efficacy that arises from socio-cultural factors, together with reductions in stereotype threat, may reduce the current disadvantages imposed by SES" .

Therefore, having clear aims for each programme (as determined within the substantive theories generated in Table 5-4 in Chapter 5) can help to foster this sense of science identity

6.2.3 Optimum science outreach model for engaging learners from a lower socio-economic background

Thus, following on from the primary data collected in both Phase One and Phase Two, along with a deeper underpinning from supporting literature, the proposed model presented Figure 6-1 was refined to create an optimum science outreach model for engaging learners from a lower socioeconomic background. The selection of the categories are summarised in Figure 6-3 and is encapsulated by focus group participants who find that "aspirations, going with the careers in science as well" is important "if you're trying to get them [the learners] to think about where it could lead them in the future and get the parents on board as well." Therefore, when designing an outreach programme that aims to engage this demographic of learners, it is suggested that an abridged version of this full model is utilised for this group of learners. Figure 6-4 presents the categories which participants believe will have the most effect when working with this group of learners making this framework more streamlined, without discounting the categories in Figure 6-1.

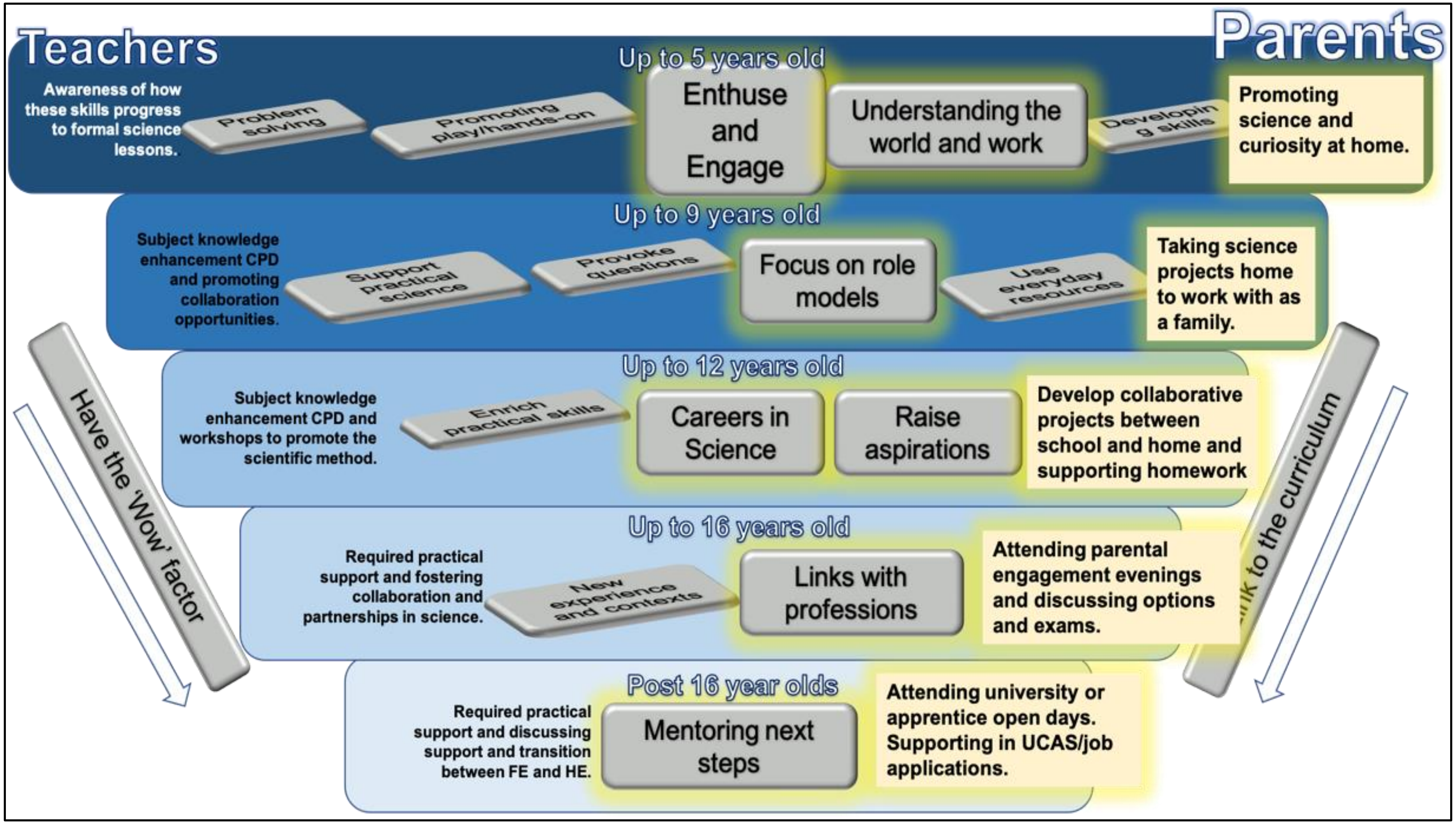

Figure 6-3 The categories from the original model that were deemed to be most important when engaging learners of a lower SES.

Age Group	For the Learners		For the Parents
Up to 5 years old	Understanding the world and work	Enthuse and engage	Promoting science and curiosity at home
Up to 9 years old	Focus on role models		Taking science projects home to work with as a family.
Up to 12 years old	Raise Aspirations	Careers in Science	Develop collaborative projects between school and home and supporting homework
Up to 16 years old	Links with professions		Attending parental engagement evenings and discussing options and exams.
Post-16 year olds	Mentoring next steps		Attending university or apprentice open days. Supporting in UCAS/job applications.

Figure 6-4 Optimum science outreach model for engaging learners from a lower socio-economic background.

6.3 Chapter Summary

This chapter presents the final version of an optimum science outreach model for the sustained impact that has been designed via input from participants in both Phases of this research study and literature that was presented in Chapter 2. The model's aim and intent have been further underpinned by additional literature within this Chapter to demonstrate how the model's design should create 'sustained impact'. Additionally, this Chapter provides a rationale for the inclusion of each stakeholder within the design (see section 6.1.2) these being the learners, their teachers and parents. These key stakeholders are important and also feature as part of the theoretical model presented by Gutman and School (2012) in their 'developmental-contextual model for career development', which underpins this research study (Figure 1-1).

This aims of this research study was to explore how science outreach may further enhance, support and encourage those learners who belong to underrepresented demographics within the STEM workforce. Socio-economic status is just one factor when considering the demographics and there are lots of other contributing predictors such as gender, self-perception of achievement and science capital that can have an impact (Gore et al, 2018). However, it is suggested that SES is likely to have the most significant effect on future career choices

(Greenhalgh, Seyan and Boynton, 2004). SES links strongly to resource availability (Gore et al., 2018), and science outreach programme often focus on providing these resources and experience to enrich formal education. Thus, participants were asked to select aspects of the model (Figure 6-1) that would have the most significant impact upon learners from a lower SES. This process created an additional model (Figure 6-4) that designers of science outreach programmes, can utilise when devising activities that target this specific group of learners. It is not intended that the more comprehensive model is inappropriate for this group of learners, but it is further refined to provide a more purposeful focus for outreach providers when working with individuals from a lower SES.

CHAPTER 7: CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

This research project aimed to explore teacher perceptions of science outreach programmes and their possible impact upon specific groups of learners. In doing so, these perceptions and experiences of teachers engaging with outreach activities in science highlighted effective practice and how these experiences could be conducive for the learners and their teachers. The data generated from this research facilitated the creation of an 'optimum science outreach model for lasting impact'. Additionally, principles of constructivist Grounded Theory (Charmaz, 2014) and data from participants within the focus groups were used to generate three substantive theories regarding teachers' perceptions of science outreach programmes. These theories are represented in Table 7-1 and whilst they are insightful in their own right; these ideas, which are grounded in data, also support the rationale of the model (represented in section 7.2.3); original data collected from the questionnaire, interviews and focus groups, along with supporting data from wider literature. The responses to the research questions (Section 7.2) have informed the recommendations for future research within the field (Section 7.3).

Table 7-1 Substantive theories generated from Phase Two Research Findings

Theory 1	The key stakeholders are part of purposeful design and delivery of science outreach programmes.
Theory 2	Purposeful design and delivery of science outreach is a way to achieve the desired outcomes of these programmes
Theory 3	The key stakeholders are part of the desired outcomes of the programmes.

Thus, this chapter summarises findings from this doctoral study and places this in the context of responding to the initial research questions. Within this chapter, the researcher also acknowledges some of the study's limitations and the intended next steps that the researcher plans to implement following this PhD study.

7.1 SUMMARY OF THE APPROACH TO THIS RESEARCH STUDY

The researcher adopted a pragmatist approach to the research study as it combined the strengths of different ideologies to offer a solution to the research questions which were defined at the start of this doctoral study (Bryman, 2012; Gole and Hirshheim, 1999). This study drew upon a range of research methods (Chapter 3) to collect data and explore the research aims (Bamkin et al, 2015). This allowed the research focus to be centred upon the design and methodology of the project providing best possible outcomes, rather than being reliant on a philosophical stance and its associated methods (Johnson and Onwuegbuzie 2004).

Following a literature review focusing upon themes central to this research study, (e.g. the impact of SES on choices in science, current practices in science outreach and the potential impact of these); the study was divided into two phases (with Phase One consisting of two stages). Phase One (Chapter 4) adopted a deductive approach whereby the findings from the literature informed the design of the questionnaire. The data collected from this questionnaire contained results from participants across the KS1 to KS5 educational settings (*n*=52) and it contained both quantitative and qualitative data. The statistical tests (Chapter 4.2.1) determined that science outreach was important for children in receipt of pupil premium (a measure of low SES in schools) and that teachers perceived that science outreach was more important at higher educational levels. The two open style free response questions were then analysed using TA (Braun and Clarke, 2006), whereby responses were coded. Initially, these codes were pre-determined by drawing upon themes from the literature review (Chapter 2), however empirical codes were also identified as not all data reflected the pre-determined codes.

Stage 2 of Phase One resulted in individual interviews (*n*=8) being conducted with participants to explore the themes in greater depth. This interview data was categorised using the same pre-determined codes from Phase One, Stage 1. Rich qualitative data was obtained from the interviews, and empirical codes were also generated during this stage. The findings from all aspects of Phase One of the study, along with ideas discussed within the literature review in Chapter 2, informed the first devised draft of the 'optimum science outreach model for lasting impact'. Thus, the rationale for each aspect of the model (Chapter 4.5) was grounded in the data collected from teachers in the North-West of England. It was further contextualised by secondary data (literature review) that adopted a more global view of science outreach practices so that the resulting model was applicable in a worldwide classroom.

Phase Two used focus groups (*n*=4) from different school phases to refine the proposed science outreach model and further understand teachers' experiences of these interventions (Chapter 5). The methodology adopted within this Phase used principles of constructivist GT (Charmaz, 2014). Adopting principles of constructivist GT meant that results generated from this phase presented substantive theories that were grounded in data and could be supported by linking these ideas to wider literature (Urquhart, 2019). The GT process also assisted with highlighting important categories and themes in relation to specific groups of learners. The focus groups provided evidence to adapt the design of the proposed model from Phase One and how to streamline this for working with children from families with a lower socio-economic status (Chapter 6.2).

7.1.1 Trustwothiness of the findings

There are some notable limitations that were encountered. These are summarised within this section to ensure transparency within the data presented and to contextualise some of the findings (Auerbach and Silverstein, 2003). This section also summarises some of the steps taken to ensure that the findings are reliable and valid.

7.1.1.1 The limitations of the data

The limitations of this research link to the scale of the study in terms of time and sample size. It had been anticipated by the researcher that there would have been a higher response rate in both Phase One and Phase Two data collections. However, Cohen et al (2018, p.44) outlines how it is not uncommon for mixed methods research to "use samples of different size, scope and types within the same piece of research". Thus, clearly aligning with a pragmatic approach to the research study.

Waiting for responses, whilst also managing the time-constraints of a full-time PhD study, meant that the researcher had to move forward with the research after the original data capture. Therefore, although the response rate to the questionnaire was lower than anticipated (n=52), the open responses were still able to generate quality descriptive data that was representative of participants across all educational levels and, although not overly large, statistical significance was determined (Chapter 4.2). This was also supported by exploring effect size, which is independent of the sample size, and therefore can be used to explore or further support substantive results, which may have been derived from the generation of a *p*-value (Field, 2013).

In Phase Two, principles of constructivist GT were adopted rather than following the methodology from a purist stance. This was due to the design of the study (two phases) and the limited theoretical sampling (using a two-wave approach) and was further justified in Chapter 5.1. (Charmaz, 2014). With regards to this methodology, Urquhart (2013) explains how a critique of the GT methodology links to the fact that theories generated are substantive in nature and the generalisability of these are somewhat limited. However, the research placed the findings from this study in the context of wider literature to review/support findings and increase the global perspective to the study.

7.1.1.2 Methods to ensure the validity of the data presented

Thus, whilst the sample is limited in terms of its size and scope of participants it did not impact on the trustworthiness of the findings presented, as several measures were taken to ensure that the results presented within this thesis remained valid and reliable. For example, in Phase One of both studies pre-pilot tests were used to ensure that questionnaire and interview questions were not misleading. The subsequent pilot study ensured that the data that would be collected from the research tools would align with the aims of Phase One and would inform the over-arching research questions (Cohen et al, 2018). Statistical tests also assisted with ensuring the data was trustworthy. The Cronbach Alpha test ensured the internal reliability of the Likert Scale questions (Davis, 2013) and the post-hoc tests ensured that the quantitative data presented was valid, including that the *p*-value was not presenting a false positive (Laerd Statistics, 2019).

Upon analysing the data, there were also several steps taken to ensure that the data presented was trustworthy. For example, the use of a 'critical friend' (which was a fellow PhD researcher) during the TA and GT coding process meant that the codes were deemed to be reliable, as this 'critical friend' agreed with the codes generated in both processes (Coghlan and Brydon-Miller, 2014). To further ensure that these results were valid, the 'critical friend' also asked the researcher to explain, justify and clarify the meaning of codes within Phase Two of the study, which meant that the codes and the categories were firmly rooted in the data (Urquhart, 2013). The two-wave approach of the GT phase meant that there was an element of member checking, which is a process that allows new participants to reflect and feedback upon the modified model (Cohen et al, 2018). Whilst this member checking was fairly informal, the fact that there were not any significant changes to be made after wave two data collection, provided the researcher with confidence in their findings.

7.2 SUMMARY OF FINDINGS

In the development of the optimised model, the stakeholders included parents and teachers, as they often influence a young person's future choices regarding science; these ideas were discussed in Chapter 2.1 and observed within the data collected from this study. Within the literature, an example of one of the theoretical models considered was the developmental-contextual model of career development, which highlights the mutual relationship between the individual and the context they are in (Vondracek et al., 1986). It explains how no singular moment can be considered as the real 'mover' for change (Schoon and Parson, 2002) for an individual, as contexts may have direct or indirect impacts on the individual dependent upon their home life, parental involvement and cultural norms (Gutman and Schoon, 2012). Thus, the models finally designed and presented in this research study (Chapter 6), consider all educational phases for the child in the English education system, including parents and schools within its construction. The inclusion of these contexts renders the findings from this research unique. The proposed model is underpinned by the theoretical understanding of what may motivate a child in science, which is subsequently translated into practice. These findings are summarised in relation to the original research questions defined in Chapter 1 of this thesis and are presented below.

7.2.1 RQ1 – How can parents, teachers and outreach programmes 'shape' a child's choice regarding science?

This question explored how extrinsic factors, such as school, home and role-models impact on a child's motivation in science and can help build an individuals' science capital. Godec, King and Archer (2017) provide an analogy of the varying degree of a student's engagement and attitudes to science and how this is like a burning candle. Whereby, the flame is the learners' engagement, the spark for this may be ignited from teachers or a particular science encounter. How well the candle continues to burn in the context of this analogy is determined by a range of external factors such as home or school or an individual's attitudes and experiences of science.

Thus, whilst the focus of this doctoral study centred around science outreach programmes, these experiences can contribute towards an individual's science capital (DeWitt and Archer, 2017) and as identified by the key dimensions of these principles (Godec, King and Archer, 2017); parents, teachers and outreach programmes have a part to play within developing this. This study utilised participants' first-hand experiences of how parents and outreach activities may impact on a child's view of science, these have been combined with supporting literature to conclude that both school and teachers have a direct impact on a child's experience of science. It is clear that teachers view outreach activities, as positive opportunities for learners to engage in science; however, the participants in this study indicate that the quality of these events are somewhat inconsistent. These ideas are captured in the literature by Yazilitas et al (2017) and Moote et al (2020) who discussed how an array of scientific evidence shows how individual, institutional and cultural factors may contribute to a person choosing to study a particular subject. Thus, findings from this sample of participants were contextualised globally using supporting literature to ensure that recommendations could be translated to wider classrooms, due to science outreach itself being a world-wide endeavour. In summary, it was found that:

(1) Home life influences pupils' engagement with outreach/science

When focusing on how parents may impact upon their child's choices about science, participants within the focus groups reflected how the varying experiences of a child's home life may impact negatively on active participation in school. The focus group participants explained how "knowing that they [their students] don't necessarily get as many opportunities, that's why we find it hard getting them on trips because they're the most scared or nervous". This notion is supported within wider literature as Vondracek et al (1986) discuss how these socialisation processes and opportunities differ between families of varying socio-economic status.

Parents are another important aspect as they are the first role model in a child's life and thus early interests are often derived from these home experiences (Chafel, 2013; Harlen, 2008; Leibham et al, 2013; Oppermann et al, 2018). Hence, the view a parent may place on their own value of science could potentially influence their child's interest. This can be further explained by referring to the theoretical underpinning of the developmental conceptual model for career development (Gutman and Schoon, 2012); as parental SES and perceived ability can impact upon career pathways. For example, if parents have a basic understanding of science, they may not advocate science as a viable career option for their child. Focus group participants recalled this parental behaviour as one of them discussed an incident where a child was supposed to be involved in a regional science competition but the "parent has pulled his child out to play a football match". They continued by explaining how the team won the science competition but felt sad as "the kid wants to be an engineer and his dad made him play football". Whilst this is not to assume that the child did not pursue STEM education, it further exemplifies how hard it is to navigate the relationship between home and school and 'shape' a child's future choices in science.

(2) Teachers are gatekeepers to pupils' access to outreach

Within schools, teachers are gatekeepers to many learning experiences for the child. Participants within this study were positive towards engaging in extra-curricular activities as they described how "I think as a general belief we are able to give anything a shot" However, they did continue to describe how they are unable to always optimise every opportunity as "it's the time, like our Head [teacher] has been really supportive in making sure we can go on it but again, once we're back, generally we're expected to write a news article". Therefore, a teacher's willingness to go above and beyond their role to provide these experiences will determine whether children engage with extra-curricular activities. Thus, this has the potential to narrow the 'opportunity gaps' that a child of a lower SES household might encounter compared to their more affluent peers (Morgan et al, 2016).

Oppermann et al (2018) discuss how motivation and beliefs about science links to self-confidence and enjoyment of the subject. Teachers must communicate scientific concepts and challenge a child's current understanding of the world (Driver et al, 2004). However, the curriculum is used as a benchmark to the content taught in science (DfE, 2013), this formal educational experience should be equal for all. What may be different is whether a child has an opportunity to engage in science outreach events, which are often used to promote science careers and increase engagement within the subject (Van der Hurk et al, 2019).

(3) Outreach must be well designed to be effective

Participants indicated how they felt that some science outreach activities' goals were seemingly not aligned with inspiring children in STEM but as a recruitment activity. It was recalled how at an event it was "almost [the provider] promoting themselves through doing the outreach for an end goal...". The findings from Banerjee (2017) suggest that the reasons for the uncertainty surrounding the impact of these outreach programmes to promote science could be attributed to the design and purpose of the outreach programme itself. For example, the participants also discussed how programmes had not been pitched at the right academic level for their students and therefore the content was inaccessible for the learners. Therefore, this study proposes that research into the success of outreach programmes need to start with an evaluation of the programmes themselves. If they are not 'fit for purpose', then it is to be expected that the impact of these will be subjective.

(4) Good outreach has potential for a range of positive impacts.

Participants within this study discussed the benefit of outreach activities for certain groups of learners, for example higher attainers and those in receipt of pupil premium. With regards to children who are from a lower SES or from socio-economically deprived areas, the participants described how "we're trying to engage them further and trying to get them to have the exact same opportunities that they might not have". The participants described how "there are kids in this school whose parents have taken them to a museum and there's kids who have never been to a museum". Therefore, science outreach programmes may provide a new experience for children who miss out on enhanced opportunities, due to their home-life. HEIs often provide outreach opportunities under the guise of WP (HEFCE, 2010), some of which take place on university premises. Attendance at science outreach events in these settings, provides insight into university life, which is often unfamiliar to an individual, especially if their parents are not educated to graduate level. Participants stated how they felt that when considering whether to go to university or not that "if someone's parents have been to university then it's significantly easier". This aligns with concerns regarding the reduced chances of disadvantaged students continuing onto higher education, particularly to study physical sciences due to a lack of parental guidance (Mujtaba et al, 2018). Participants described that attending outreach events were "good for relationships as well", as teachers used it as an opportunity to find capture and apply what motivates their own students back in the science classroom.

7.2.2 RQ2 - What do teachers in the North-West of England think about science-based outreach programmes, especially in the context of children's social demography?

Participants in this study expressed how engaging with outreach providers is a worthwhile endeavour. However, their responses alluded that their perceptions and experience of these events can influence their own motivation to engage in these activities. Therefore, although it was agreed that outreach activities can impact upon specific groups of learners, the experiences were of value to the teachers too. Ultimately, as teachers are gatekeepers to these opportunities, it is important to consider this during the planning stage of each science outreach programme. To further summarise the thoughts of participants in relation to RQ2, presented below is a broad coverage of ideas of key aspects of outreach design (Radon and Gammons, 2014).

Who are science-outreach programmes important for?

When considering for whom these science-based outreach programmes are important, 'the learners' and 'the teachers' were identified within this data as key stakeholders within the design and the delivery of the outreach programme. However, a key finding from Phase One was that "students will respond to science outreach programmes in different ways", dependent on their attitude towards school and/or their demographic. Interview participants further captured these ideas as they suggested how outreach activities "can motivate, but it depends upon whether the students involved are enthusiastic" and that "it is very pupil dependent". Glover et al (2016) presented similar findings when asking teachers who the chemistry outreach programme they were engaged with, would impact on.

It was concluded that, whilst teachers did think that science outreach programmes were significantly important for pupil premium students, statistical analysis of the questionnaire (Chapter 4) revealed that teachers perceived no difference in importance of science outreach programmes for male or female students. Whilst it was encouraging to see how this sample of teachers from this study did not think gender should be a contributing factor for targeting gender in science, literature indicated that many programmes were aimed at girls in science. The wider research presents that women in physical science particularly, were an underrepresented group (Dubetz and Wilson, 2013; Griffin and Hu, 2015; Ivie and Langer-Tesfaye, 2012; Mujtaba and Reiss, 2013). Therefore, the research from this study does not concur with these ideas presented within the wider literature. The researcher suggests that this may be due to limited sample size of the participants, and the skew towards females within the study. However, it could also be that as this has been a group that has been given a lot of precedence (APPG, 2020), teachers are more aware of promoting this type of equity within their classroom. This is an aspect that could explored further in future research studies.

It has been noted in Section 7.2.1, how participants believed that science outreach programmes could assist learners from disadvantaged backgrounds. Phase Two participants stated that science outreach experiences may help to "raise aspirations" of this group of learners as they meet "people like them who have come from similar backgrounds", providing role-models which could impact on their lives (Cridge and Cridge, 2015). Ideas regarding science-based outreach programmes supporting this group of learners, were streamlined within the 'optimum science outreach model' for engaging learners from a lower socio-economic background presented in Figure 6-4 in section 6.2. These categories mainly centred around focusing on role models, raising aspirations and including parents within these programmes.

What should science outreach programmes look like and where might they take place?

Responses from participants in this research study, identified key aspects that should be considered within the design of an outreach programme, these include:

- Allow hands-on access to different resources and types of activities.
- Provide a wider knowledge of careers available in science.
- Show how science is applied in a real-life context.
- Involve external partners.

These responses from participants within the North-West of England align with ideas from Jeffers et al's (2004) STEM outreach framework, Gumaelius et al's (2016) review of the different STEM outreach programmes and Gall et al's (2020) discussion regarding these programmes taking place within and outside of school.

Other key factors to consider linked to 'the outreach programme content' and the 'logistics' of the delivery of the activities. The participants stated that these activities needed to be accessible in terms of time and cost, but also link to formal statutory education outlined by government, as one participant stated, "the curriculum is king". The participants alluded that the activities can be difficult to organise especially "without a supportive head teacher". Thus, the design of science outreach programmes need to consider; how they are perceived by senior leaders in schools, how the benefits of the outreach activities will align with school initiatives and ultimately convince a head teacher why they should allow teachers to take children out of formal lessons. This links to the discussions in Section 7.2.1 and further strengthens the position of teachers being gate keepers, a unique finding in this evidence-based study.

Why do teachers choose to engage with science outreach programmes?

Whilst the response to 'why' teachers chose to engage with science outreach has been discussed in previous chapters, some notable reasons which emerged from participant responses centred on the theme that 'science outreach assists with learning'. For example, a participant described how "we have had a number of organisations visit our school over the past 10 years" and "all experiences have excited our children and supported teaching and learning." Whilst it is encouraging to see how these informal learning activities can assist the formal curriculum, this is more than an 'add on benefit' as participants within the focus-groups indicated that they would only be able to partake in these programmes if they linked directly to the National Curriculum (DfE, 2013). Seton, Mallaburn and Goodwin (2018, p.27) attributed the success of their chemistry outreach programme to several key features such as "its in-school, compulsory nature" which is facilitated by a teaching practitioner who is familiar with the National Curriculum. Thus, aligning these programmes with curricular based learning would reduce initial barriers for engaging in outreach activities as they would be an effective use of curriculum time.

Although teachers in this research study discussed how important 'learning' was as part of these outreach programmes, when asked about the benefits, most of the responses centred around learners enjoying the experiences, being challenged and improving softer skills like "self-confidence and self-esteem". The teachers also stated that these experiences provided the opportunity to further develop positive relationships with their students and further understanding their individual needs as "it allows us to see that there's a gap there in those skills as and well, and that is something we need to develop with those students". This directly reflects the wider discussions from participants in Phase Two of the research study in contributing to the generation of the 'changing minds' and 'positive impacts' categories in the proposed model.

Whilst engagement with science outreach programmes is linked to extra-curricular activities, many participants incited that these experiences were integral to the curriculum. For example, it was identified how "I don't really think about any of that stuff [outreach activities] as sort of being separate to the curriculum, for me it's really part of the curriculum". However, these events take time to organise and require teachers to go "above and beyond" their current employment remit. This conflict regarding teachers' engagement with science-based outreach programmes, is captured within participant responses who were clear of the benefits these experiences would have on their learners. Although, they explained that the "danger is that, as teachers are so over worked, the activities become forgotten". Thus, those who design and deliver such programmes need to understand how they can target their programmes and appeal to schools in the first instance. They also need to ensure that there is a positive take-away experience for both students and teachers, even if they were not those they had anticipated when agreeing to attend an event. The findings in this study reflect Glover et al's (2016) findings regarding the mismatch between why teachers chose to engage with outreach programmes and the reported benefits of their engagement.

When do teachers think science-outreach programmes should happen?

The robust data collected from this study indicated that that outreach programmes should be able to be accessible throughout all educational stages and ideally as a sustained sequence of events, rather than stand-alone experiences. These two recommendations are discussed:

Age at which science outreach should be targeted:

Teachers within this sample initially perceived a significant difference in the importance of science outreach work at different educational levels. Questionnaire data concluded that older students benefited more than younger counterparts. A possible reason for this response from the teachers is it is harder to measure the impact of outreach activities with younger learner's future career choices (MacLean, 2017; Wilson and Chizeck, 2000). However, as teachers were questioned during the interviews and focus group stages of this study, it was clear that they valued these experiences happening at a much younger age as; "children seeing early on, real-life applications of science" and "looking at careers earlier" gives them "something to aspire to". The participants also suggested within Phase Two, that the proposed model needed an additional 'layer' to extend the framework for younger children. This resulted in the introduction of the lowest age category on the model (up to 5 years old). This idea aligns with ideas previously discussed regarding motivation in science (Eccles et al, 1993; Maltese and Tai, 2010; Marsh et al, 2001 and Oppermann et al, 2017).

Frequency of each outreach programme:

It was found that teachers have more confidence in the benefits of outreach programmes when they can establish sustained relationships with the providers. Participants discussed how "when you've worked with them [the science outreach provider] for so long you know what you're going to get, and you know these people." This indicates that establishing prolonged relationships with outreach providers, could in turn increase the frequency of how often activities take place. Thus, it was agreed by participants and supported by Vennix et al (2017), that long-term partnerships may have a more positive impact upon students and teachers alike (Seton et al, 2018; RSC, 2020).

As previously highlighted, although participants have discussed how they want to engage with these programmes; time, money and senior leadership in schools, are barriers to accessing them. Some participants outlined how, the frequency of these events is "not as much as it used to be" and when they do get the opportunity to engage with events, "usually this seems to take place as 'one off' days". Whilst some participants from this study, supported by Cridge and Cridge (2015), worried that these short-term experiences are unlikely to have a significant impact upon an individual's choices, there were examples of where these one-off events notably had. For example, a focus group participant described a one-off event whereby they received a box of resources to continue the activities within school. An interview participant explained how following a single event at a university, a student applied for that science-related course. Thus, whilst longitudinal science outreach programmes can provide a more sustained experience for the teachers and the learners, which is mutually beneficial for the schools and the outreach providers, well planned stand-alone events can also be meaningful.

7.2.3 RQ3 - How can science outreach become a more effective intervention tool within the classroom?

This doctoral study suggests that by focusing on how outreach activities can support a learner's experience in science, and key stakeholders (such as parents and teachers) should be included, then the sustainability of these activities can be improved. Although these findings are detailed in Chapter 6, the proposed final model is represented in Figure 6-1 in Chapter 6.1. These original findings are important as other research has indicated that the impact of these on future choices in science is much more subjective (Banerjee; 2017; Landry et al 2019; Vennix et al, 2018).

The generation of Figure 6-1 is based on primary data collected throughout the doctoral study and supported with the findings from an extensive literature review in Chapter 2, which became more focused in Chapters 4-6. Each aspect of the model has been informed by participants within this research study and wider literature, to ensure that the findings are placed within a global context. For example, the inclusion of 'role models' and linking with professionals stemmed from several suggestions by participants who felt that "role models are important" and that "getting role models who've come from similar sort of backgrounds from what they've [the learner] come from" is crucial. Participant's ideas reiterated findings regarding the improving equity in STEM education agenda, by enabling individuals to see how science relates to them and their personal upbringing (APPG, 2020). Therefore, ensuring that this is incorporated within the design of an outreach programme will support a more diverse STEM workforce in the future. Each aspect is similarly justified within Chapters 4, 5 and 6 and Table

7-1. The theories in Table 7-1 portray how having clear aims and objectives to a science outreach programme, that include key stakeholders will make the desired outcomes more achievable. These outcomes are dependent on the initial aims of the programme but should include increasing engagement in science within underrepresented groups, inspiring young people to persist in STEM and supporting learning. Comparing these theories in Table 7-1 with the 'optimum model' in Figure 6-1 this framework aims to support those who design and facilitate outreach programmes. The activities delivered must be purposeful to meet the needs of all the key stakeholders, impacting upon a child's choice regarding science.

7.3 Recommendations and Future Research

Based on the findings from this research study, this penultimate section summarises key recommendations for improving the practice of science outreach programmes in the context of policymakers, outreach providers and schools.

7.3.1 Key recommendations

Within the data collected, not one participant suggested that science outreach activities were not a worthwhile endeavour. Therefore, it can be concluded that these science outreach experiences contribute to an individual's science capital, whereby an individual adds positive ideas and experiences to their understanding of science (Godec, King and Archer 2017). Thus, by improving outreach provision by making them more purposeful and considering further involvement of key stakeholders, can be beneficial to all stakeholders. The aims of this doctoral study focused upon gaining further understanding of teacher's perceptions of outreach programmes. The data from Phase One of the study was used to devise a unique framework that could inform the design and delivery of outreach programmes in science. During Phase Two, the model was further developed and refined, resulting in substantive theories which were generated and grounded in data (see Table 7-1). By refining the model and developing these theories, both processes supported and strengthened the findings presented. The findings from this study support teachers and schools engaging with science outreach programmes whilst also providing a framework for outreach providers and policymakers. Thus, the key recommendations are summarised below in the context of the appropriate stakeholder and exemplified with a brief example/rationale from this research study. Including parents within the practices of science outreach.

It is proposed that those who design the outreach programmes themselves should consider how to involve parents in these experiences. For example, when participants were asked how these programmes benefit different groups of learners, they all agreed that disadvantage students benefitted greatly. The participants also highlighted how they "think it [an outreach activity] is for all children, not just pupil premium" students, and "parental input" for these students, was deemed to be the most important. These findings align with the conceptual framework underpinning this research study 'The developmental-contextual model of career development' (Gutman and Schoon, 2012), indicated that parental SES can influence a child's choice throughout all stages of schooling. Thus, based on the data collected in this study and wider literature, the researcher developed the model to include parents to increase its sustainability over time. Parents are key stakeholders, as they influence a child's choice in relation to being enthusiastic about science (Section 7.2.1). This recommendation may also impact upon schools' motivation to engage with these events. Participants highlighted how managing relationships between school and home can be difficult and improving this aspect would be beneficial to all.

7.3.1.1 Using formal frameworks (such as the models presented within this study) to assist the design and delivery of outreach programmes can contribute to a more consistent, sustained and meaningful experience for audiences.

This recommendation is important for all key stakeholders but is of particular importance for policymakers in science and those which provide the programmes. Incentives and widening participation (WP) programmes such as science outreach programmes are used to promote STEM based careers for all. However, participants from this study discussed how their experiences of these activities were somewhat inconsistent. Focus group participants described how at times these events could be "almost like a free for all". Thus, significant funds are invested in these activities and at times, they are having the desired impact, and this is not economically beneficial. When participants were asked to comment upon the proposed framework presented in Figure 6-1 they discussed how they thought it was extremely useful as "usually you wouldn't think of them [science outreach programmes] as strategically as you [the researcher] have done on here." This example of the positive response towards the model(s) demonstrated how strategically designing outreach programmes provokes a positive response from the key gatekeeper to the activities in school. Thus, it is to be concluded that to make science outreach sustainable and have the desired impact; a framework such as that provided in Figure 6-1 can be beneficial, as involving other stakeholders in the events, can influence a young person's future choices.

For those stakeholders who are involved with the design and delivery of science outreach programmes, this model can assist with developing age-appropriate and relevant content. For example, when critiquing the model during the focus groups, participants commented how some experiences with outreach providers were less worthwhile, as the delivers of the activities "did not know their target audience", and there was only "one level of differentiation". It was described by participants as "a car crash because someone comes in and they're trying to communicate to a blanket audience". Thus, having categories within the model which supports the demands of the National Curriculum (DfE, 2013) can ensure that activities are age appropriate and reflect the correct academic level. Having a programme which supports, enhances and extends the formal learning in science may promote learner's positive attitudes towards science, which Oppermann et al (2018) suggests can impact upon their future decisions regarding science.

Finally, whilst it is recommended that these outreach experiences need to be more sustained, no outreach encounter should be discounted, because if these activities are well planned, they can still influence children. Hence, quality outreach is favoured over the quantity of delivery. Participants suggested that these quality experiences should support curriculum learning, focus on pupil enjoyment and include professional development opportunities for teachers. In doing so, this could appease some of the stress participants associated with organising extra-curricular outreach activities.

7.3.1.2 Outreach needs to be accessible to teachers/schools as these are gatekeepers to these experiences.

The above recommendation considers the needs and logistics of school, and thus is of particular importance for those who facilitate the science outreach programmes. Understanding the 'bigger picture' of daily routines in school, current government agendas and the constraints and demands of the formal curriculum, is useful when forming partnerships with schools. Participants discussed how "the only hard thing about what you're doing is the time it [outreach events] takes to plan as a teacher" as "you are having to do your job first…and then that's on top". Thus, building their needs into an outreach programme can further support teachers in their own practice. This could be achieved by adding some CPD aims to the overall design of a science outreach programme, even if only to provide teachers with different pedagogical approaches for more difficult conceptual understanding through observations of the facilitators and their activities. Thereby, including CPD (as suggested by a number of participants within this study, see section 4.2.2.1) will impact upon children, as arranging to attend these events quantifies the "extra-work" as 'worthwhile', as the teachers benefit too. Jeffers et al (2004, p.95) agrees as their proposed framework suggested that 'curriculum supplements' and 'K-12 teacher involvement' were key features within STEM outreach programmes.

7.3.1.3 Science outreach should support learners across all educational stages, including younger learners and transitions between school levels.

Science policymakers and outreach providers, should consider designing and promoting outreach activities to younger individuals. Participants discussed at what age science outreach should be delivered, and those who worked with younger learners, were keen to ensure there was support for 3–7-year-olds. Literature supports this, as it has been found that interests form at an early age (Eccles et al, 1993; Maltese and Tai, 2010; Marsh et al, 2001 and Oppermann et al, 2018). In addition, a focus upon role models and potential careers were advocated as features of these programmes for younger children. This is of particular use for policymakers who still recognise the difference in uptake of STEM subjects by different groups (CASE, 2018), as providing more guidance at a younger age can encourage more children to continue into HE (Banerjee, 2018).Participants also commented how they "like how it goes from 10-12 years old" as "it's like transition support", which is commonly highlighted in literature as a time where there may be a regression in attitudes towards science (Braund, 2016; Braund and Hames, 2005; DeWitt, Archer and Osbourne, 2014). Thus, having outreach programmes which are 'continuous' throughout the move from primary to secondary school in England could alleviate some of these difficulties.

7.3.2 RECOMMENDATION FOR FUTURE RESEARCH

In terms of future research, following the completion of this Doctoral study, future work would be centred on testing the model designed and ensuring findings are published within peer reviewed journals. In terms of the next steps of testing the model, this would involve developing and delivering outreach programmes that have been formulated using the framework presented as part of this science outreach model that has been developed as part of this PhD study. In testing the model, there would also be a focus on collecting further data to improve and extend the model's utility. It is anticipated that this would be achieved by utilising additional stakeholder voices, such as those of the learners or the parents and also collecting a larger and wider geographical sample. This would further contextualise the utility of the model in an international context. Further details of this future research is outlined in the subsequent sections.

7.3.2.1 Collecting further data

Both the theories depicted in Table 7-1, and the models proposed are grounded in data generated from this doctoral study; the design of the research, has enabled the proposed models to be refined by participants through focus group meetings. Therefore, it is anticipated that future research would consider the appropriateness of the proposed models, by using the framework to inform providers of age-appropriate activities and measuring the impact of these.

The model presents a unique framework that has been underpinned by both data from this study and wider literature. It should be used as a tool to plan purposeful activities for a specific age range, with resources that support teachers, the curriculum and parents. Then, using feedback (along with clearly defined measurements of impact) from multiple stakeholders (outreach providers, schools, and policymakers) the effectiveness of this model can be determined. Wood (2014) discusses the importance of having clearly agreed scales of measurement for impact, to focus upon areas of academic achievement or social change. Social change recognises a transformation that occurs for individuals, groups or nations at a cultural or economical level. Focusing upon social measures in future research within this field is of particular importance, as GCSE reforms indicate that the gap in attainment between disadvantaged children and their more affluent counterparts in science may be growing (Burgess and Thompson, 2019). In addition to this, the global CoVid-19 pandemic, which resulted in closure of schools across the UK (DfE, 2020), is anticipated to have future impact on the attainment of disadvantaged students, as the progress made to narrow this gap in the last decade has since been reversed (EEF, 2020).

Whilst the rationale for the potential impact of this research on science outreach programmes is clear, findings could be aligned to outreach endeavours in other subjects. This is because, although participants within this study were asked about science activities and the rationale behind advocating particular pedagogies (such as using a more hands-on approach), this is also transferable to other subjects. Also, the participants within this sample are from schools based within the North-West of England so it would be advantageous to repeat Phase Two with participants in other parts of England, the UK and in other countries. Understanding the conceptions of teachers not only provides a critique of science outreach programmes and insights as to why these gatekeepers choose to engage with these activities, but capturing teachers' perceived impact upon an individual enhances the process. Testing the null hypotheses presented within Phase One of the study, with a larger sample, would further explore the wider themes linked to outreach programmes such as gender and age. Additionally, it would be beneficial to explore parents' perceptions of outreach activities, as they have a central role in shaping a child's choice in relation to science and helping to build their science capital (Gordec et al, 2017) (see section7.2.1).

Finally, for future research in the field, there should be further focus upon the wider and softer skills developed by the individual, when they partake in these programmes. Not all the benefits that are associated with these types of activities will result in a child choosing to pursue a higher degree in science, although it can have a lasting impact on their mind-set or life experiences. This has been noted in participant examples from this research study, and too often this type of impact is not the focus of measurement when monitoring these interventions. Therefore, data (utilising validated surveys for example) could be collected from the learners and wider stakeholders about additional benefits such as increasing confidence, improving communication and increased aspiration. This could assist with providing further clarity of the benefits of school outreach activities and why it is a worthwhile endeavour.

7.3.2.2 Disseminating findings

Following the submission of this thesis, a small number (possibly two or three) journal papers will be drafted, which capture the findings of this research and submitted to appropriate peer-reviewed journals. Birks and Mills (2011) suggest that this is the most appropriate way to disseminate original research. For example, one paper will capture findings from Phase One and will disseminate teachers' general perceptions of science outreach programmes by using primary data in this doctoral study. Then subsequently, papers presenting the theories generated from the grounded theory process and the model itself will be published. Upon reflection of the research design, the researcher will write a journal article that focuses on the methodological approach to Phase Two. The researcher feels this latter publication would be useful in the context of education, as many papers which depict a modified grounded theory approach were found to be amongst nursing journals rather than from an educational perspective.

7.4 CONCLUSION AND PERSONAL REFLECTION

When reviewing original data from this research study and wider literature that reviewed the practice of science outreach programmes and their potential impact, there were many benefits cited. These included increasing enjoyment in science and promoting novel ‘hands-on’ experiences (Gall et al, 2020; Landry et al, 2019; Vennix, den Brok and Taconis, 2018). There is a wealth of discussion focussed upon how these experiences are of particular importance for disadvantaged learners (Griffin and Hu, 2015; Mujtaba eta al, 2018; See et al, 2012), younger learners (MacLean, 2017; Maltese and Tai, 2010; Wilson and Chizeck, 2000) and teachers who encounter these (Jeffers et al, 2004; Mintzes et al, 2013; Murcia and Pepper, 2018; Shanahan et al, 2011). However, there remains a lack of evidence that outreach influences school aged learners' career choices (Banerjee, 2017; Banerjee, 2018; Bogue et al, 2013; Van De Hurk et al, 2019). CASE (2018) outlines how STEM related careers are expected to continue to rise until 2023 at double the amount compared to alternative careers. In the UK, this of a particular concern with the uncertainties of Brexit, as 32% of the HE STEM academics are from outside the UK (compared to 25% in non-STEM disciplines). Therefore, nurturing children and to persist within STEM in regions that do not usually entice locals within this field is of national importance.

At present, toolkits such as those prepared by the Higher Education Funding Council for England (HEFCE) (Dent et al, 2014), provide guidance for practitioners delivering and designing outreach programmes, however these are generic and designed specifically for HEIs. There remains a lack of guidance to improve practice, and as such, this doctoral research provides a unique, focused and evidence-based tool to support these activities to make them more effective. Both models generated (see Figure 6-1 and Figure 6-4**Error! Reference source not found.**) p rovide a framework for the design and delivery of outreach programmes so they have a sustainable impact. This definition of ‘impact’ aligns with multiple definitions explored by Chandler (2014, p.2), such as the “influence of research or effect on an individual, community” or “the demonstrable contribution that excellent research makes to society and the economy” This means that this academic research is to be of benefit to those facilitators in science outreach programmes. Conducting this research study has allowed me to explore and advocate the potential of utilising science outreach programmes to promote science to wider audiences. It has always been my belief that no individual should feel excluded from being part of the scientific community, due to where they come from and the community to which they belong. As an individual that experienced education in a 'deprived' area but was able to successfully navigate their way into science, this was due to encouragement from both parents and teachers. Therefore, it is crucial that these two stakeholders are discussed more objectively and openly. At present, science outreach may not have all the answers to solving this problem regarding equity in STEM careers, but these programmes provide extra opportunities for increasing positive attitudes towards science. Thus, this research has reaffirmed the 'power' of these informal science learning experiences and I am confident that having a more systematic approach to design of delivery will further promote this.

7.5 CHAPTER SUMMARY

This chapter recalls and responds to the key research questions that were set out in the initial chapter of this doctoral study. It outlines the steps that were taken to collect primary data and also how literature was used to further underpin the design and development of a unique model, which can be used to assist with making science outreach programmes more purposeful and effective. This chapter also reflects upon some of the limitations within the design on this PhD study; these are mostly related to time and funding constraints. However, the research used a pragmatic approach to collect the data within the two phases of this study and drew upon different methods to be able to determine key recommendations that have been presented within section 7.3. It is anticipated that these will provide a unique contribution regarding research within the practice of science outreach. Therefore, the findings will expand and provide new perspectives upon literature within this field.

REFERENCES

Abrahams, I. (2011) *Practical Work in secondary science: A minds in approach,* Continuum International Publishing Group, London.

Abrahams, I. and Millar, R. (2008) "Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching and learning method in school science?" *International Journal of Science Education,* 30(14/17), 1945–1969.

Abrahams, I., Reiss, M., & Sharpe, R. (2014). The impact of the 'Getting Practical: Improving Practical Work in Science' continuing professional development programme on teachers' ideas and practice in science practical work. *Research in Science & Technological Education, 32*(3), 263-280.

ACS Hillington (2018) *Year/Grade Placement* [online]
Available: https://www.acs-schools.com/acs-hillingdon-class-ages
[Accessed: 20th March 2018]

Addi-Raccah, A. and Israelashvili, M. (2014) 'The Long-Term Effects of a University Outreach Programme: Implications on Higher Education Enrolment '*Higher Education Policy*, 27(1), 111–130.

Alexander, H., Waldron, A. M, & Abell, S. K. (2011) 'Science and Me: A Student-Driven Science Outreach Program for Lay Adult Audiences' *Journal of College Science Teaching,* 40(6), 38-44.

Alldred, P., Fox, N., & Kulpa, R. (2016) 'Engaging parents with sex and relationship education: A UK primary school case study', *Health Education Journal, 75*(7), 855-868.

Allen, B. (2008) 'Postmodern Pragmatism: Richard Rorty's Transformation of American Philosophy', *Philosophical Topics*, 36(1), 1-15.

Allen, R. and Sims, S. (2017) *Improving Science Teacher Retention* [online]
Available: https://wellcome.ac.uk/sites/default/files/scienceteacher-retention.pdf
[Accessed 29th March 2019]

Anderhag, P., Emanuelsson, P., Wickman, P. and Hamza, K. M (2013) 'Students' Choice of Post-Compulsory Science: In search of schools that compensate for the socio-economic background of their students' International Journal of Science Education, 35 (18), 3141-3160.

APPG on Diversity and Inclusion in STEM (2020) *Inquiry in Equity in STEM Education; Final Report* [online]
Available:https://www.britishscienceassociation.org/Handlers/Download.ashx?IDMF=debdf2fb-5e80-48ce-b8e5-53aa8b09cccc
[Accessed 21st July 2020]

Archer, L., Dawson, E., DeWitt, J., Seakins, A. & Wong, B. (2015) "'Science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts'. *J Res Sci Teach*, 52, 922-948.

Archer, L., Dawson, E., DeWitt, J., Godec, S., King, H., Mau, A., Nomikou, E. and Seakins, A. (2016) *Science Capital Made Clear* [Online]
Available: https://www.stem.org.uk/sites/default/files/pages/downloads/Science-Capital-Made-Clear.pdf
[Accessed 17th May 2021]

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012) 'Science Aspirations and family habitus: How families shape children's engagement and identification with science', *American Educational Research Journal*, 49(5), 881–908.
Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2103) 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspirations' *Pedagogy. Culture and Society,* 21(1), 171-194.

Archer, L. DeWitt, J. & Wong, B. (2014) 'Spheres of influence: what shapes young people's aspirations at age 12/13 and what are the implications for education policy?', *Journal of Education Policy*, 29(1), 58-85.

Archer, L., Moote, J., Francis, B., DeWitt, J. & Yeomans, L. (2017) 'Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to 'Triple Science' at KS4 in England', *Research Papers in Education*, 32(3), 296-315, DOI: 10.1080/02671522.2016.1219382

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). *ASPIRES 2: Young people's science and career aspirations, age 10-19*. London: UCL Institute of Education.

Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B. & Willis, B. (2013) *ASPIRES: young people's science and career aspirations, age 10-14*. London, UK: King's College London

Arksey, H. and Knight, P. (1999) *Interviewing for Social Scientists*. London: Sage.

Armitage, A, (2007) 'Mutual Research Design: Redefining Mixed Methods Research Design', *British Educational Research Association Annual Conference*, University of London, 5-8 September 2007.

Aslam, F., Adefila, A. and Bagiya, Y. (2018). 'STEM Outreach Activities: An Approach to Teachers' Professional Development', *Journal of Education for Teaching,* 44 (1), 58-70.

Asumus, A. and Schroeder, J. (2016) 'Rethinking Outreach: Collaboration Is Key for Herbicide-Resistance Management' *Weed Science*, 64, 655-660.

Atkinson, J. W. (1950) 'Studies in projective measurement of achievement motivation', *Microfilm Abstracts*, 10(4), 290-291.

Attride-Stirling, J. (2001) 'Thematic Networks an Analytic Tool for Qualitative Research', *Qualitative Research*, 1(3), 385-405.

Auerbach, C. F. and Silverstein, L. B. (2003) *Qualitative Data: An Introduction to Coding and analysis.* New York: New York University Press.

Avery Gomez, E., Wu, D. & Passerini, K. (2010) 'Computer-supported team based learning: The impact of motivation, enjoyment and team contributions on learning outcomes', *Computers & Education*, (55) 378–390.

Avraamidou, L. (2014) 'Studying science teacher identity: current insights and future research directions', *Studies in Science Education*, 50 (2), 145-179.

Avvisati, F., Gurgand, M., Guyon, N. & Maurin, E. (2014) 'Getting Parents Involved: A Field Experiment in Depreived schools', *Review of Economic Studies*, 81(1), 51-83.

Bamkin, M.; Maynard, S. and Goulding, A. (2016) 'Grounded theory and ethnography combined', *Journal of Documentation*, 72(2), 214-231.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Banerjee, P. A. (2015) 'Can schemes to inspire tomorrow's scientists close the poverty attainment gap?' *The Conversation* [online]
Available: https://theconversation.com/can-schemes-to-inspire-tomorrows-scientists-close-the-poverty-attainment-gap-35805
[Accessed 24th April 2019]

Banerjee P. A. (2016) 'A longitudinal evaluation of the impact of STEM enrichment and enhancement activities in improving educational outcomes: Research protocol', *International Journal of Educational Research,* 76 (1), 1-11.

Banerjee, P. (2017) 'Is informal education the answer to increasing and widening participation in STEM education?' *Review of Education*, 5(2), 202–224.

Banerjee, P. A. (2018) 'Widening participation in higher education with a view to implementing institutional change', *Perspectives: Policy and Practice in Higher Education,* 22 (3), 75-81.

Barrance, R. & Elwood, J. (2018) 'National assessment policy reform 14–16 and its consequences for young people: student views and experiences of GCSE reform in Northern Ireland and Wales', *Assessment in Education: Principles, Policy & Practice*, 25(3), 252-271.

Barrera, D. (2015) 'Examining Our Interdependence: Community Partners' Motivations to Participate in Academic Outreach', *Journal of Higher Education Outreach & Engagement*, 19(4), 85–113.

Barrett, A., Kajamaa, A. and Johnston, J. (2020) 'How to … be reflexive when conducting qualitative research', *The Clinical Teacher,* 17(1), 9-11.

Baruch, J. (2014) 'Practical science has a global reach and appeal', *Nature,* **507**(7491), 141.

Becker, H. Geer, B., Hughes, E.C., Elliot, H. & Strauss, A. (1977) *Boys in White: Student Culture in Medical School.* New Brunswick, NJ: Transaction.

Bedford, S. (2017) 'Growth mind-set and motivation: a study into secondary school science learning', *Research Papers in Education*, 32(4), 424-443.

Bell, A. (2020) 'Building Science Capital through Family Science', *Primary Science*, 161, 28-31.

Bellibas, M. (2016) 'Who are the Most Disadvantaged? Factors Associated with the Achievement of Students with Low Socio- Economic Backgrounds', *Kuram Ve Uygulamada Egitim Bilimleri,* 16(2), 691-710.

Berger, R. (2015) 'Now I see it, now I don't: researchers position and reflexivity in qualitative research', *Qualitative Research,* 15(2), 99-102.

Berkowitz, R., Moore, H., Astor, R. A., & Benbenishty, R. (2017) 'A Research Synthesis of the Associations between Socioeconomic Background, Inequality, School Climate, and Academic Achievement', *Review of Educational Research*, 87(2), 425–469.

Bevins, S., Brodie, M. and Brodie, E. (2005) 'A study of UK secondary school students' perceptions of science and engineering' *European Educational Research Association Annual Conference,* Dublin, 7-10 September 2005.

Bibbings, L. S. (2006) 'Widening Participation and Higher Education', *Journal of Law & Society*, 33(1), 74-92.

Birks, M. & Mills, J. (2011). *Grounded Theory: A practical guide*. London: Sage

Blackie, N. (2007) *Approaches to Social Inquiry*, 2nd Edition. Cambridge; Polity Press.

Blackmore, K., Howard, C. & Kington, A. (2018) 'Trainee teachers' experience of primary science teaching, and the perceived impact on their developing professional identity', *European Journal of Teacher Education*, 41(4), 529-548.

Blickenstaff, J. C. (2005) 'Women and science careers: Leaky pipeline or gender filter?' *Gender and Education*, 17(4), 369–386.

Bloor, M., Frankland, J., Thomas, M. & Robson, K. (2001) *Focus Groups in Social Research.* London: SAGE Publications Ltd.

Blowers, E. J. (2018) 'An Investigation of Professional Integrity in Pre-registration Nurse Education: A Modified Grounded Theory Research Study' *Nurse Education Today*, 68, 40–44.

Blums, A. Jay Belsky, Kevin Grimm & Zhe Chen (2017) 'Building Links between Early Socioeconomic Status, Cognitive Ability, and Math and Science Achievement', *Journal of Cognition and Development*, 18(1), 16-40.

Boaler, J, Altendorff, L. and Kent, G. (2011) 'Mathematics and science inequalities in the United Kingdom: when elitism, sexism and culture collide', *Oxford Review of Education*, 37(4), 457-484.

Boersema, D. (2002) 'Introduction: Pragmatism and Neopragmatism', *Essays in Philosophy,* 3(2), Article 12.

Bogue, B., Cady, E. T. & Shanahan, B (2013) 'Professional Societies Making Engineering Outreach Work: Good Input Results in Good Output', *Leadership & Management in Engineering*. 3(1), 11-26.

Bonferroni, C. E. (1936) `Teoria statistica delle classi e calcolo delle probabilità', *Pubblicazioni del R Istituto Superiore di Scienze Economiche e Commerciali di Firenze,* 8, 3-62.

Borrego, M. Douglas, E.P. and Amelink, C. T. (2009) Quantitative, Qualitative, and Mixed Research Methods in Engineering Education. *Journal of Engineering Education*, 98(1), 53–67.

Bourdieu, P. (1977) *Outline of a Theory of Practice.* Cambridge: Cambridge University Press.

Bourdieu, P. (1990) *In other words: An essay towards a reflective sociology*. Standford, CA: University Press.

Boyer, E. L. (1996) 'The Scholarship of Engagment', *Journal of Public Service and Outreach,* 1 (1), 11-20.

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), 77-101.

Braun, V. & Clarke, V. (2013). Successful Qualitative Research: A Practical Guide for Beginners. Sage.

Braund, M. "Progression and Continuity in learning" IN: Wellcome Trust (2009) *Perspectives of Education in Primary-Secondary transfer in science*. Issue 2; London, Education.

Braund, M., & Driver, M. (2005) 'Pupils' perceptions of practical science in primary and secondary school: Implications for improving progression and continuity of learning', *Educational Research, 47*(1), 77-91.

Braund, M., & Hames, V. (2005) 'Improving progression and continuity from primary to secondary science: Pupils' reactions to bridging work', *International Journal of Science Education, 27*(7), 781-801.

Braund, M. (2016) 'Oh No, Not This Again! Improving Continuity and Progression from Primary to Secondary Science', *School Science Review,* 362, 9.

Brennan, V. K., Mallaburn, A. and Seton, L. (2018) Teachers' perception of chemistry outreach work, especially in the context of children's social demography. *Teacher Education Advancement Network Journal,* 10 (2) 3-14.

Brewin, M., & Statham, J. (2011) 'Supporting the transition from primary school to secondary school for children who are looked after', *Educational Psychology in Practice*, 27(4), 365-381 DOI: 10.1080/02667363.2011.624301

Broecke, S. (2013). Does offering more science at school increase the supply of scientists? *Education Economics, 21*(4), 325-343.

Brown, K. (2018) 'The Effects of a University Research Reactor's Outreach Program on Students' Attitudes and Knowledge about Nuclear Radiation. *Research in Science and Technological Education,* 36(4) 484-498.

Brown, J. B. (1999) 'The use of focus groups in clinical research'. In B. F. Crabtree, & W. L. Miller (Eds.), *Doing qualitative research.* 2nd Edition. Thousand Oaks, CA: Sage. 109-124

Bru, E. Stomes, T. Munthe, E. and Thuen, E. (2010) 'Students perceptions of teacher support across transition from primary to secondary school', *Scandinavian Journal of Educational Research,* 56(6), 519-533.

Bruner J. (1996) *Toward a Theory of Instruction*. Cambridge. MA: Belkapp

Bruner, J. (2004) 'Narrative of Science' n E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer90-98.
Bryman, A. (2012) *Social Research Methods* 4th Edition, Oxford: Oxford University Press.

Bryman, A. (2016) *Social Research Methods* 5th Edition, Oxford: Oxford University Press.

Bulmer, M. (1979) 'Concepts in the Analysis of Qualitative Data', *Sociological Review*, 27, 651-677.

Burgess, S. and Thomson, D. (2019) Making the Grade. *The Sutton Trust* [online].
Available:https://www.suttontrust.com/wp-content/uploads/2019/12/MakingtheGrade2019.pdf
[Accessed 27th July 2020]

Burns, J. (2018) Teacher numbers at lowest since 2013 official figures show. *BBC News* [Online].
Available: https://www.bbc.co.uk/news/education-44648438
[Accessed 23rd June 2020]

Burton, L. D. Kijai, J. And Sargeant, M. A. (2005) 'The Relationship Between Students' Perceptions of the Teaching and Learning Process and Academic Performance in Science of Seventh and Eighth Graders Enrolled in Seventh-day Adventist Schools' *Journal of Research on Christian Education*, 14(2), 177-212.

Bybee, R., Taylor, J. and Gardener, A. (2006) 'The BSCS 5E instructional model' *Origins and effectiveness.* Colorado Springs, CO: BSCS.

Cabrera, A. F., & La Nasa, S. M. (2001) 'On the path to college: Three critical tasks facing America's disadvantaged', *Research in Higher Education*, 42(2), 119-149.

Cadwallader, S. (2019) 'The impact of qualification reform on the practical skills of A level science students. Paper 5: Final report on the pre- and post-reform evaluation of science practical skills' *Ofqual*, [Online].
Available:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793227/A_level_science_Paper_5FINAL.pdf
[Accessed 27th July 2020]

Cambridge Dictionary (N.d.) 'Enrich" [Online]
Available: https://dictionary.cambridge.org/dictionary/english/enrich
[Accessed 7th April 2020]

Campaign for Science and Engineering (CASE) (2014) 'Improving Diversity in STEM' [Online].
Available: www.sciencecampaign.org.uk/resource/ImprovingDiversityinSTEM2014.html
[Accessed: 30th September 2016]

Campaign for Science and Engineering (CASE) (2018) 'Policy Review Diversity' [Online].
Available: https://www.sciencecampaign.org.uk/static/uploaded/f3c01267-0a43-40a5-8014124b27ffb052.pdf
[Accessed: 11th January 2021]

Canadian Space Agency (2016). 'Inspiring resources for Young People' [Online]
Available: https://www.asc-csa.gc.ca/eng/resources-young/default.asp
[Accessed 15th December 2016]

Carmines, E., and Zeller, R., (1979). *Reliability and Validity Assessment*. California: Sage Publications. California.

Carter, I. (2014). Is This the End of the English Tradition of Practical A-Level Science? *School Science Review,* 96(355), 12-14.

Chafel, J. A. (2003) 'Socially Constructing Concepts of Self and Other through Play', *International Journal of Early Years Education*, 11 (3), 213-222.

Chambers, D. (1983). 'Stereotypic Images of the Scientist: The Draw-a-Scientist Test', *Science Education,* 67(2): 255–265.

Champagne, M. V. (2014) *The Survey Playbook; How to create the perfect survey*. CreateSpace Independent Publishing Platform [Online].
Available: www.createspace.com
[Accessed 19th October 2018]

Chandler, C. (2014) 'What is the meaning of Impact in relation to research and why does it matter? A view from inside academia' IN *Achieving Impact in Research*. Demicolo, P. (Ed.) London: SAGE Publications Ltd. 1-9.

Charmaz, K. (2000) 'Grounded Theory: Objectivist and constructivist methods' in, Gubrium, J. F. and Holstein, J. A. (eds), *Handbook of Qualitative Research: Context and Method*, Thousand Oakes, CA: SAGE. 509-535.

Charmaz, K. (2002). Grounded theory analysis. In Gubrium, J. F. & Holstein, J. A. (Eds.), *Handbook of interviewing research*. Thousand Oaks, CA, Sage. 675–694

Charmaz, K., (2004) 'Premises, principles, and practices in qualitative research: revisiting the foundations', *Qual. Health Res.* 14(7), 976–993.

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage.

Charmaz, K. (2008). 'Constructionism and the Grounded Theory', IN Holestein, J. A. and Gubrium, J. F. (Eds.) *Handbook of Constructionist research*, New York: The Guilford Press. 397-412.

Charmaz, K. (2014) *Constructing Grounded Theory*, 2nd Edition, London, SAGE Publications Ltd.

Charmaz, K. (2017a) 'Constructivist grounded theory', *The Journal of Positive Psychology,* 12(3), 299-300.

Charmaz, K. (2017b) 'Special invited paper: Continuities, contradictions, and critical inquiry in grounded theory', *International Journal of Qualitative Methods*, 16(1), 1–8

Charmas, K. and Bryrant, A. (2010) 'Grounded Theory' in Charmaz, K. and Bryant, SA. (Eds.) *The SAGE Handbook of Grounded Theory* [Online].
Available: https://uk.sagepub.com/en-gb/eur/the-sage-handbook-of-grounded-theory/book234413
[Accessed 17th March 2018]

Charmaz, K. and Mitchell, R. G. (2001) 'Grounded Theory in Ethnography' in Atkinson P., Coffey, A., Delamont, S. Lofland, J. & Lofland, L. (Eds) *Handbook of Ethnography*, London: SAGE. 160-176.

Check J. W. (2002). *Politics, language, and culture: A critical look at urban school reform*. Westport, CT: Praeger.

Check, J., & Schutt, R. K. (2012). Research methods in education. Thousand Oaks, CA: Sage

Cheyne JA, Tarulli D. (2005) 'Dialogue, Difference and Growth in the Development of ZPD', in Daniels, H. (Ed.) *An Introduction to Vygotrsky.* Routledge: Oxon.

Christodoulou, A. (2017) 'Engaging in and with research to improve STEM education', *Research Papers in Education*, 32(4), 535-537.

Cicourel, A. V. (1964) *Method and Measurement in Sociology*, New York: The Free Press.

Clarke, A. E. (2005) *Situational analysis: Grounded theory mapping after the postmodern turn*. Thousand Oaks, CA: Sage.

Clarke. V. and Braun, V. (2017) 'Thematic Analysis', *The Journal of Positive Psychology*, 12(3), 297-298.

Cleaves, A. (2005). 'The formation of science choices in secondary school'. *International Journal of Science Education*, 27(1), 471–486.

Clement, J. J., and Stephens, A. L. (2008) 'Anchoring Student Reasoning in Prior Knowledge: Characteristics of Anchoring Cases in a Curriculum', *NARST (National Association of Research in Science Teaching),* 2008 Annual Meeting.

Cobern, W. W and Loving, C. C (2004) 'Defining Science in a Multicultural World' n E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer , 195-214.

Coe, R. (2002) 'It's the Effect Size, Stupid. What effect size is and why it is important' *British Educational Research Association*, University of Exeter, England, 12-14.

Coghlan, D., & Brydon-Miller, M. (2014) *The SAGE encyclopaedia of action research (Vols. 1-2).* London: SAGE Publications Ltd.

Cohen, J. (1988) *Statistical power analysis for the behavioural sciences*, 2nd edition. Hillsdale, NJ: Lawrence Earlbaum Associates.

Cohen, L.; Manion, L. and Morrison, K. (2018) *Research Methods in Education*, 8th Edition, Oxon: Routledge.

Colgan, L., (2016) 'Hey it's Elementary: Choose a path that includes Math' *Gazette - Ontario Association for Mathematics*, 55(2), 11–13.

Collins, J. A. and Fraser, B. C. J. M. (2005) 'Balancing the strengths of systematic and narrative reviews', *Human Reproduction Update*, (11)2, 103–104.

Collins, S., Reiss, M., & Stobart, G. (2010) 'What happens when high-stakes testing stops? Teachers' perceptions of the impact of compulsory national testing in science of 11-year-olds in England and its abolition in Wales', *Assessment in Education: Principles, Policy and Practice*, 17(1), 273–286.

Collinson, G. (2014) 'The view from schools on provision of careers information, advice and guidance in STEM subjects', *School Science Review*, 96(355), 19-27.

Cone, J., Rowe, S., Borberg, J. , Stancioff, E. , Doore, B. & Grant, K. (2013) 'Reframing Engagement Methods for Climate Change Adaptation', *Coastal Management*, 41(4), 345-360,

Copper, K. and Stewart, K. (2013) *Does money affect children's outcomes?* [Online], 22nd October 2013 Joseph Rowntree Foundation [Online]
Available: https://www.jrf.org.uk/report/does-money-affect-children%E2%80%99s-outcomes [Accessed 22nd June 2020]

Constan, Z. and Spicer, J. J. (2015) 'Maximizing Future Potential in Physics and STEM: Evaluating a Summer Program Through a Partnership Between Science Outreach and Education Research', *Journal of Higher Education Outreach and Engagement*, 19(2). 117-135.

Coward, K. and Gray, J. V. (2014) 'Audit of Practical Work Undertaken by Undergraduate Bioscience Students Across the UK Higher Education Sector. Project Repor't. *Royal Society of Biology* [Online].
Available: https://www.rsb.org.uk/images/SB/UG-Practical-Work-Report-Web.pdf
[Accessed 16th April 2017]

Creswell, J.W. (2002) *Research design: Qualitative, quantitative, and mixed methods approaches*. New York: Sage Publications.

Creswell, J.W., and V.L. Plano Clark. (2011). *Designing and conducting mixed methods research*. 2nd Edition. Thousand Oaks, CA: Sage Publications.

Cridge, B.J and Cridge, A. G. (2015) 'Evaluating How Universities Engage School Students with Science: A Model Based on the Analysis of the Literature. *Australian Universities' Review*, 57(1), 34-44.

Cripps Clark, J., Tytler, R., & Symington, D. (2014) 'Bringing authentic science into schools', *Teaching Science: The Journal of the Australian Science Teachers Association*, 60(3), 28–34.

Crotty, M. (1989). *The foundations of social research.* London: Sage.
Crowley, K. (2001) 'Parents Explain More Often to Boys than to Girls during Shared Scientific Thinking', *Psychological Science,* 12(3), 258

Dahl, R. M. and Droser, M. L. (2016) 'Building an Effective and Affordable K-12 Geoscience Outreach Program from the Ground Up: A Simple Model for Universities' *Journal of Geosceince Education*, 64(1), 5-16.

Daniels, H. lauder, H. and Porter, J. (2009) 'Introduction: From Plato to Monday Morning' In Daniels, H. Lauder, H. and Porter, J. (Eds) *Educational Theories, Cultures and Learning. A Critical Perspective*. Oxon: Routledge. 1-6.

Darlington, H. (2015) 'Increasing students' interest in science: the contribution of practical work', *School Science Review,* 96(357), 105-113

Darlington, Y. and Scott. D. (2002) *Qualitative research in practice: Stories from the field*. Buckingham; Open University Press.

Davies, M. B. (2007) *Doing a successful research project*. Basingstoke: Palgrave Macmillian.

Davis, C. (2013) *SPSS Step by Step: Essentials for Social and Political Science*: Bristol: Policy Press.

De Mulder, E. F.J., Eder, W. Mogessie, A., Ahmed, E. A. E., Da Costa P, Y. D., Yabi, I., and Cloeting, S. A. P. L (2014) 'Geoscience outreach in Africa, 2007–2013', *Journal of African Earth Sciences*, 99(1), 743–750

De Vaus, D. (2013). *Surveys in social research.* London: Routledge.

Deci, E. L. & Ryan, R. M. (2000) 'The 'what' and 'why' of goal pursuits: human needs and theself-determination of behavior', *Psychological Inquiry*, 11(1), 227–268.

Deci, E. L. and Ryan, R. M. (2015) 'Self-Determination Theory,' Editor(s): James D. Wright, *International Encyclopedia of the Social & Behavioral Sciences.* 2nd Edition. London:Elsevier, 486-491.

DeCoito, I. (2016) 'STEM Education in Canada: A Knowledge Synthesis', *Canadian Journal of Science, Mathematics and Technology Education*, 16(2), 114-128.

Deemer, E. D., Thoman, D. B., Chase, J P., & Smith, J. L. (2014). 'Feeling the Threat: Stereotype Threat as a Contextual Barrier to Women's Science Career Choice Intentions.' *Journal of Career Development,* 41(2), 141-158.

Deng Z. (2012) 'School Subjects and Academic Disciplines-The Differences' In Luke, Allan, et al. *Curriculum, Syllabus Design and Equity: A Primer and Model*, [Online]
Available: ProQuest Ebook Central,
http://ebookcentral.proquest.com/lib/ljmu/detail.action?docID=1020267
[Accessed 31st October 21016]

Denscombe, M. (2008) 'Communities of Practice: a research paradigm for the mixed methods approach, *Journal of Mixed Methods Research,* 2(3), 270-283.

Dent, P. Garton, L. Tristram Hooley, T. Leonard, C. Marriott, J. and Moore, N. (2014) *Higher Education Outreach to Widen Participation. Toolkits for practitioners*, 3rd Edition. London: Higher Education Funding Council for England (HEFCE) by the International Centre for Guidance Studies and The Progression Trust.

Denzin, N. K. (2012) 'Triangulation 2.0', *Journal of Mixed Methods Research,* 6(2), 80–88.

Department for Business, Innovation and Skills (DBIS) (2014) *National Strategy for Access and Student Success in Higher Education* London: DBIS [Online]
Available:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/299689/bis-14-516-national-strategy-foraccess-and-student-success.pdf
[Accessed 17the June 2017]

Department for Education (DfE) (2011) *A Profile of Teachers in England in from the 2010 Workforce Census' Education Standards Analysis and Research Division* [Online].
Available:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182407/DFE-RR151.pdf
[Accessed 23rd June 2020]

Department for Education (DfE) (2013) *The National Curriculum* [Online]
Available: http://www.education.gov.uk/schools/teachingandlearning/curriculum [Accessed 16th September 2016]

Department for Education (DfE) (2014) *GCE AS and A level subject content for biology, chemistry, physics and psychology* [Online].
Available: https://www.gov.uk/government/publications/gce-as-and-a-level-for-science
[Accessed 13th August 2020]

Department for Education (DfE) (2013) *Early years foundation stage statutory framework (EYFS)* [Online].
Available: https://www.gov.uk/government/publications/early-years-foundation-stage-framework--2
[Accessed 11th September 2020]

Department for Education (DfE) (2018) *Careers guidance and access for education and training providers* [Online].
Available: https://www.gov.uk/government/publications/careers-guidance-provision-for-young-people-in-schools
[Accessed 13th August 2020]

Department for Education (DfE) (2020) *Actions for schools during the coronavirus outbreak* [Online].
Available: https://www.gov.uk/government/publications/covid-19-school-closures/guidance-for-schools-about-temporarily-closing
[Accessed 8th June 2020]

Desouza, J. M. S. (2017) 'Conceptual play and science inquiry: using the 5E instructional model', *Pedagogies: An International Journal,* 12(4), 340-353.

Dewey, J. (1915) 'The Subject-Matter of Metaphysical Inquiry', *The Journal of Philosophy, Psychology and Scientific Methods,* 12(13), 337-345.

Dewey, J. (1931) 'George Herbert Mead'. *The Journal of Philosophy'*, 28(12). 309-314.

Dewey, J. (2008). Experience and nature. In J. Boydston & S. Hook (Eds.) *The later works of John Dewey, 1925-1953*Carbondale: Southern Illinois University Press. Vol. 1, pp. 1-437. (Original work published 1925)

Dewey, J. (2008). Human nature and conduct. In J. Boydston & G. Murphy (Eds.), *The middle works of John Dewey, 1899-1924*. Carbondale: Southern Illinois University Press. (Vol. 14, pp. 1-227). (Original work published 1922)

DeWitt, J. and Archer, L. (2017) 'Participation in informal science learning experiences: the rich get richer?', *International Journal of Science Education, Part B*, 7(4), 356-373

DeWitt, J. Archer, L. and Mau, A. (2016) 'Dimensions of science capital: exploring its potential for understanding students' science participation'*, International Journal of Science Education*, 38(16), 2431-2449.

DeWitt, J., Archer, L., & Osborne, J. (2014) 'Science-related aspirations across the primary-secondary divide: Evidence from two surveys in England', *International Journal of Science Education*, 36(10), 1609–1629.

Dolan, E. and Dolan, E. L. (2008) *Education Outreach and Public Engagement*, New York, NY: Springer.

Domingos, A. M. (1989) 'Conceptual Demand of Science Courses and social Class'. In Adey, P. Bliss, J., Head, J. and Shayer, M. (Eds) *Adolescent Development and School Science.* Lewes: Falmer Press.

Donnelly, J. (2006) 'The intellectual positioning of science in the curriculum, and its relationship to reform', *Journal of Curriculum Studies*, 38(6), 623–640.

Driver, R. Asoko, H. Leach, J. Mortimer, E. and Scott, P. (2004) 'Constructing Scientific Knowledge in the Classroom' n E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer, 58-73.

Dubetz, T. A. and Wilson, J. A. (2013) 'Girls in Engineering, Mathematics and Science, GEMS: A Science Outreach Program for Middle-School Female Students', *Journal of STEM Education, Innovations and Research,* 4(3), 41-47.

Dudovskiy, J. (nd) *Research Methodology-Purposive Sampling* [Online].
Available: http://research-methodology.net/sampling-in-primary-data-collection/purposive-sampling
[Accessed 13th October 2016]

Dunn, O. J. (1964) 'Multiple comparisons using rank sums', *Technometrics*, 6(1), 241-252.

Dyer, R., Venton, B., & Maeng, J. (2018) 'Expanding University Student Outreach: Professional Development Workshops for Teachers Led by Graduate Students', *Journal of Chemical Education,* 95(11), 1954-1959.
Education, Audiovisual and Culture Executive Agency (EACEA) (n.d.) 'Leonardo Da Vinci Programme' [Online].
Available: https://eacea.ec.europa.eu/sites/2007-2013/llp/leonardo-da-vinci-programme_en
[Accessed 24th June 2020]

Eaude, T. (2011) *Thinking though Pedagogy for Primary and Early Years.* Exeter: Learning Matters Ltd.

Eccles, J. (1983). 'Expectancies, values, and academic behaviors'. In Spence, J. T (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* San Francisco, CA: W. H. Freeman. 75-146

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993) 'Age and gender differences in children's self- and task perceptions during elementary school', *Child Development*, 64(3), 830.

Edmonds, J., Lewis, F. and Fogg-Rogers, L. (2018) 'Practical Steps to Building Science Capital in the Primary Classroom', *Primary Science,* 154, 29-31.

Education Endowment Foundation (EEF) (2018) *The Attainment Gap 2017* [Online].
Available:https://educationendowmentfoundation.org.uk/public/files/Annual_Reports/EEF_Attainment_Gap_Report_2018.pdf
[Accessed 8th June 2020]

Education Endowment Foundation (EEF) (2019) *The EEF Guide to The Pupil Premium* [Online].
Available:https://educationendowmentfoundation.org.uk/public/files/Publications/Pupil_Premium_Guidance_iPDF.pdf
[Accessed 8th June 2020]

Education Endowment Foundation (EEF) (2020) *Impact of school closures on the attainment gap: Rapid Evidence Assessment* [Online].
Available:https://educationendowmentfoundation.org.uk/covid-19-resources/best-evidence-on-impact-of-school-closures-on-the-attainment-gap
accessed 8th June 2020

Egalite, A. J. and Kisida, B. (2018) 'The effects of teacher match on students' academic perceptions and attitudes', *Educational Evaluation and Policy Analysis*, 40(1), 59–81.

Eilam, E., Bigger, S. W., Sadler, K., Barry, F., & Bielik, T. (2016) 'Universities Conducting STEM Outreach: a Conceptual Framework', *Higher Education Quarterly*, 70(4), 419-448.

Eng, E. and Febria, C. (2011) 'Utilizing Science Outreach to Foster Professional Skills Development in University Students', *Collected Essays on Learning and Teaching*, 4(1), 58-67.

Ercikan, K. and Roth, W. M. (2006) 'What good is polarizing research into qualitative and quantitative?', *Educational Researcher,* 35(5), 14-23.
Erol, M., Buyuk, U., & Onal, N. T. (2016) 'Rural Turkish Students' Reactions to Learning Science in a Mobile Laboratory', *Educational Sciences: Theory & Practice*, 16(1), 261-277.

Ezzy, D. (2002) *Qualitative Analysis: Practice and Innovation*, London: Routledge.

Farquhar, C. and Das, R. (1999) 'Are focus groups suitable for "sensitive" topics? In Bardour, R. and Kitzinger, J. (eds.) *Developing Focus Group Research: Politics, Theory and Practice.* London: Sage.

Fakayode, S., Pollard, D., Snipes, V., & Atkinson, A. (2014) 'Offering a Geoscience Professional Development Program To Promote Science Education and Provide Hands-On Experiences for K-12 Science Educators', *Journal of Chemical Education, 91*(11), 1882-1886.

Falk, J. H. and Needham, M. D. (2011) 'The Impact of a Science Center on Its Community', *Journal of Research in Science Teaching*, 48 (1), 1-22.

Fensham, P. (2004) "School science and its problems with scientific literacy" n E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer,. 21-36.

Fensham, P. (2009) 'The link between policy and practice in science education: The role of research', *Science Education*, 93(6), 1076–1095.

Fidler, P. (2010) *Assessing the Impact of UK Science and Discovery Centres: Towards a set of common indicators* [Consultation Document]. UK: UK Association for Science and Discovery Centres.

Field, A. (2013) *Discovering Statistics Using SPSS* (Fourth Edition), CA, SAGE Publications Ltd.

Fleer, M. and Rillero, P. (2008) 'Family involvement in science education: where are the outcomes for parents and students?' *Studies in Science Education*, 34(1), 93-114.

Fletcher, S. (2016) 'Australian National University Science Extension Day', *Teaching Science,* 62(1), 40-42.

Flick, U. (2019) 'Grounded theory coding: Ways and Versions', IN: Flick, U. (ed.) *Doing Grounded Theory*, London, SAGE Publications Ltd, 49-66.

Flynn, N. (2005) 'Science Days: An Interdisciplinary Outreach Program', *Journal of Chemical Education,* 82(10), 1483-1485.

Forsyth, A. and Furlong, A. (2003) 'Access to Higher Education and Disadvantaged Young People', *British Educational Research Journal*, 29(2), 205-225.

Foucault, M. (1972) *The archaeology of knowledge* (A. M. Sheridan Smith, Trans). New York, NY: Pantheon Books.

Fretterman, D. M. (2010) *Ethnography: Step by Step*, (3rd Edition) London: SAGE.

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, 32(200), 675–701.

Friedman, H. H. and Amoo, T. (1999) 'Rating the rating scales,' *Journal of Marketing Management,* 9 (2), 114-123.

Fullbright Commission (n.d.) *US School system* [Online].
Available: http://www.fulbright.org.uk/study-in-the-usa/school-study/us-school-system [Accessed 13th February 2017]

Gale, T., Sellar, S., Parker, S., Hattam, R., Comber, B., Tranter, C. & Bills, D. (2010) *Interventions early in school as a means to improve higher education outcomes for disadvantaged (particularly low SES) students, A design and evaluation matrix for university outreach in schools* [Policy document] Australia: The Department of Education, Employment and Workplace Relations, Commonwealth of Australia.

Gall, A. J, Vollbrecht, P. J., & Tobias, T. (2020) 'Developing outreach events that impact underrepresented students: Are we doing it right?', *European Journal of Neuroscience,* 00, 1-8.

Galletta, A. (2012) *Mastering the Semi-Structured Interview and Beyond from Research Design to Analysis and Publication*, New York: New York University Press.

Gatsby Foundation. (2013) *Good Career Guidance.* [Online:}
Available at: https://www.gatsby.org.uk/education/focus-areas/good-career-guidance [Accessed 25th January 2021]

Gatt, S. and Costa, M. F. P. C. M. (2009) 'Networking School Teachers to Promote Better Practice in the Teaching of Science across Europe', *European Journal of Education,* 44(4), 493-507.

Gershon, M. (2013) *How to Use Questioning in the Classroom: The complete Guide*, Marston Gate: Amazon.co.uk

Gibney Wall, C. R. and Musetti, B. B. (2018) 'Beyond Teaching English: Embracing a Holistic Approach to Supporting English Learner Students and Their Families' *The CATESOL Journal*, (30) 2, 1- 17.

Gibson, W. J. and Brown, A. (2009) *Working with Qualitative Data,* London: SAGE Publications Ltd.

Gill, T. and Bell, J. F. (2013) 'What Factors Determine the Uptake of A-level Physics?', *International Journal of Science Education*, 35(5), 753-772.

Gillham, B. (2005) *Research interviewing the range of techniques*, Berkshire: Open University Press.

Gillham, B. (2008) *Small-Scale Social Survey Methods*, London: Continuum Books.

Gillies, V. and Alldred, P. (2002) 'The ethics of intention: research as a political tool' IN Mauthner, M.; Birch, J. Jessop, T. and Miller, T. (eds) *Ethics in Qualitative Research*, London: SAGE.

Glaser, C. V. (1978) *Theoretical Sensitivity: Advances in the Methodology of Grounded Thoery*, Mill Valley, CA: Sociology Press.

Glaser, B. G. (1992) *Basics of Grounded Theory Analysis: Emergence Vs Forcing*, Mill Valley, CA: Sociology Press.

Glaser, B. G. (2005) *The Grounded Theory Perspective III: Theoretical Coding,* Mill Valley, CA: Sociology Press.

Glaser, B. G. (2012) 'Stop. Write! Writing Grounded Theory', *The Grounded Theory Review*, (11)1, 2-11.

Glaser, G. V. and Strauss, A. L. (1967) *The Discovery of Grounded Theory*, Chicago, IL: Aldane.

Glover, S.R., Harrison, T. G., & Shallcross, D. E. (2016) 'Why do Secondary School Chemistry Teachers Engage in long-term Outreach partnership with a university?', *Acta Didactica Napocensia,* 9(2), 79-97.

Godec, S.; King, H. & Archer, L. (2017) 'The science Capital Teaching Approach: engaging students with science, promoting social justice. London; University College London.

Gokpinar, T. and Reiss, M. (2016) 'The role of outside-school factors in science education: a two-stage theoretical model linking Bourdieu and Sen, with a case study', *International Journal of Science Education*, 38(8), 1278-1303.

Goldkuhl, G. (2012) 'Pragmatism vs interpretivism in qualitative information systems research', *European Journal of Information Systems,* (21)2, 135-146. http://dx.doi.org/10.1057/ejis.2011.54\

Goles T, and Hirschheim, R. (2000) 'The paradigm is dead, the paradigm is dead … long live the paradigm: the legacy of Burell and Morgan', *Omega*, 28, 249-268.

González, R. L. and Jackson, C. L. (2013) 'Engaging with parents: the relationship between school engagement efforts, social class, and learning', *School Effectiveness and School Improvement,* 24(3), 1-20.

Goodman, B. E. (2002) 'Evolution of a Partnership to improve K-16 Science Education', *Advances in Physiology Education*. 26 (3), 168-173.

Gorard, S. (2012) 'Who is eligible for free school meals? Characterising free school meals as a measure of disadvantage in England', *British Educational Research Journal*, 38(6), 1003-1017.

Gorard, S. and See, B. H. (2008) 'Is Science a Middle-Class Phenomenon? The SES determinants of 16-19 participation', *Research in Post-Compulsory Education*, 13(2), 217-222.

Gorard, S. & See, B. H. (2009) 'The Impact of socio-economic status on participation and attainment in science', *Studies in Science Education*, 45(1), 93-129.

Gorard, S., Boliver, V., Siddiqui, N. & Banerjee, P. (2019) 'Which are the most suitable contextual indicators for use in widening participation to HE?', *Research Papers in Education*, 34(1), 99-129.

Gorard, S., See, B.H. and Smith, E.(2008) *The impact of SES on participation and attainment in science – a review of available data* [Online].
Available:https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2008/4294969756.pdf
[Accessed 12 April 2017]

Gore, J. Patfield, S. Holmes, K. and Smith, M. (2018) 'Widening participation in medicine? New insights from school students' aspirations' *Medical Education,* 52, 227-238.
Gottfredson, L. S. (1981) 'Circumscription and compromise: A developmental theory of occupational aspirations', *Journal of Counselling Psychology*, 28, 545–579.

Gouthier, D.; Manzoli, F. & Ramani, D. (2008) 'Scientific careers and gender differences. A qualitative study', *International School for Advanced Studies,* 7(1), 1-3.

Gov.uk (2019) *School workforce in England:* November 2018 [Online].
Available: https://www.gov.uk/government/statistics/school-workforce-in-england-november-2018
[Accessed 23rd June 2020]

Gov.uk (2020) Student Finance, [Online].
Available: https://www.gov.uk/student-finance
[Accessed 23rd June 2020]

Grabau, L. J. & Ma, X. (2017) 'Science engagement and science achievement in the context of science instruction: a multilevel analysis of U.S. students and schools', *International Journal of Science Education*, 39(8), 1045-1068.

Greany, T., Gu, Q., Handscomb, G. & Varley, T. (2014) 'School-University Partnerships: Fulfilling the Potential Summary report' *Bristol: National Coordination Centre for Public Engagement*, Swindon, Research Councils UK.

Greene, J. C (2008) 'Is mixed methods social inquiry a distinctive methodology?' *Journal of Mixed Methods Research*, 2(1) 7-22.

Greener, I. (2011) *Designing Social Research: A Guide for the Bewildered,* London: Sage Publications Ltd.

Greenfield, S. (2004) 'The Child' In E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer. 41-57.

Greenfield, S. (2010) *Block 2 Interviews DVD-ROM. SEH806 Contemporary Issues in Science Learning*, Milton Keynes: The Open University.

Greenhalgh, T., Seyan, K., & Boynton, P. (2004) '"Not a university type": Focus group study of social class, ethnic, and sex differences in school pupils' perceptions about medical school', *British Medical Journal, 328*(7455), 1541-1544A.

Griffin, B., & Hu, W. (2015) 'The interaction of socio-economic status and gender in widening participation in medicine', *Medical Education,* 49(1), 103-113.

Guba, E. (1990) *The paradigm dialog.* Newbury Park, CA: Sage.

Guile, D. & Young, M. (1998) 'Apprenticeship as a conceptual basis for a social theory of learning', *Journal of Vocational Education and Training*, 50, 173-192.

Gumaelius, L., Almqvist, M., Árnadóttir, S., Axelsson, A., Conejero, J. A., García-Sabater, J. P. & Voss, M. (2016) 'Outreach initiatives operated by universities for increasing interest in science and technology', *European Journal of Engineering Education*, 41(6), 289-622.

Gutman, L.M., and Schoon, I., (2012) 'Correlates and consequences of uncertainty in career aspirations: Gender differences among adolescents in England', *Journal of Vocational Behavior* , 80(3), 608-618.

Güven, U. and Akçay, A. O. (2019) 'Trends of Homework in Mathematics: Comparative Research Based on TIMSS Study', *International Journal of Instruction*, 12(1), 1367-1382.

Haak, D. C., HilleRisLambers, J., Pitre, E. & Freeman, S. (2011) 'Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology' *SCIENCE*, 332, 1213-1216.

Hackman, D. (2009) 'Socioeconomic Status and the Developing Brain', *Trends in Cognitive Sciences,* 13(2), 65.

Hammersley, M. (2011) *Methodology: Who needs it?* London: Sage.

Hammersley, M. and Atkinson, P. (2007) Ethnography: principles in practice, (3rd Edition) Oxon: Routledge.

Hampden-Thompson, G., and Bennett, J. (2013) 'Science teaching and learning activities and students' engagement in science', *International Journal of Science Education*, 35(8), 1325–1343.

Hanson,J., Moore, N. Clark, L. and Neary, S.(2021) 'An evaluation of the North East Pilot of the Gatsby Benchmarks of Good Career Guidance'.
Available: https://www.gatsby.org.uk/uploads/education/ne-pilot-evaluation-full-report.pdf
[Accessed: 23rd June 2021]

Hansen, A. (2011) *Primary professional Studies,* Exeter: Learning Matters Ltd.

Harackiewicz, J. M., Pozek, C. S., Hulleman, C. S. & Hyde, J. S. (2012) 'Helping Parents to Motivate Adolescents in Mathematics and Science: An Experimental Test of a Utility-Value Intervention', *Psychological Science*, 23(8), 899–906.

Harlen, W (2008) 'Science as a key compound of the primary curriculum; a rationale with policy implications' IN: Wellcome Trust (2008) *Perspectives in Education: primary science.* Issue 1. London: Education.

Harris, T. (2015) 'Grounded Theory', *Nursing Standard*, 29(35), 32-39.

Harrison, M. (2016) 'Making practical work work: Using discussion to enhance pupils' understanding of physics', *Research in Science & Technological Education,* 34(3), 290-306.

Harrison, T.G., Norman, N.C. & Shallcross, D.E., (2016) 'What can be learnt from the Bristol ChemLabS centre for excellence in teaching and learning 10 years on?, Education in Chemistry', *Royal Society of Chemistry*, 53(2), 26-29.

Harsh, J. A.; Maltese, A. V. & Tai, R. H. (2012) 'A Perspective of Gender Differences in Chemistry and Physics Undergraduate Research Experiences', *Journal of Chemistry. Education,* 89(11), 1364-1370.

Hartley, M. and Treagust, D. (2014) 'Learner perceptions of the introduction of computer-assisted learning in mathematics at a peri-urban school in South Africa', *Learning Environments Research,* 17(1), 95-111.

Hartley, M. S., Treagust, D. F. & Ogunniyic, M. B. (2008) 'The application of a CAL strategy in science and mathematics for disadvantaged Grade 12 learners in South Africa', *International Journal of Educational Development*. 28, 596–611.

Hashweh, M. Z. (1987) 'Effects of subject-matter knowledge in the teaching of biology and physics', *Teaching and Teacher Education*, 3(2), 109–120.

Hattie, J. (2009) *Visible Learning*. London: Routledge.

Hattie, J. (2012) *Visible Learning for Teachers*. London: Routledge.

Harris, A., and Goodall J. (2008) 'Do Parents Know They Matter? Engaging All Parents in Learning', *Educational Research,* 50(3), 277–289.

Heddy, B. C. and Sinatra, G. M. (2017) 'Transformative parents: Facilitating transformative experiences and interest with a parent involvement intervention', *Science Education*, 101, 765-786.

Higher Education Funding Council for England (HEFCE) (2010) *Aimhigher summer schools: Participants and progression to higher education,* England: Higher Education Funding Council for England

Helms, J. V. (1998) 'Science – and me: Subject matter and identity in secondary school science', *Journal Research in Science Teaching,* 35, 811–834.

Hetherington, S. (1999): 'Knowing Failably', *The Journal of Philosophy,* 96(11), 565–587.

Hitchcock, G. and Hughes, D. (1995) *Research and the Teacher*, (2nd Edition) London: Routledge.

HM Treasury (2015) 'North West long term economic plan as set out by the Prime Minister and Chancellor' [Online].
Available: https://www.gov.uk/government/news/long-term-economic-plan-for-the-north-west-set-out-by-prime-minister-and-chancellor
[Accessed 28th October 2016]

HMSO (2002) 'House of Commons Science and Technology Committee, Science education from 14-19', Third report of session 2001-2002.
Available:
https://publications.parliament.uk/pa/cm200102/cmselect/cmsctech/1204/120402.htm
[Accessed 17th July 2017]

Hodson, D. (1998) *Teaching and learning science towards a personalized approach*, Maidenhead: Open University Press.

Holliman, R. & Jessen, J. (2009) '(In)authentic science and (im)partial publics; (re) constructing the science outreach and public engagement agenda'. In Holliman, R. Whitelegg, E. Scanlon, E., Smidt, S. and Thomas, J. (eds.) *Investigating Science Communication in the Information Age: Implications for public engagement and popular media*. Oxford, UK: Oxford University Press, 35–52.

Holmes, A., Bradley, G., Carslie, T. & Lhuede, K. (2014) 'Developing performance indicators for homeless outreach psychiatric services', *Australian Psychiatry,* 22(2), 160-164.

Horner, S. (2011) 'Scientific Inquiry: mere pedagogy or real science? And who decides?' IN: Wellcome Trust *Perspectives of Education: Inquiry-based teaching*, London: Wellcome Trust.

House of Commons (2002) '*Science Education for 14-19'*, Volume 1: Report and Proceedings of the Science and Technology Committee (HC 508-1), London, The Stationary Office Ltd.

Hughes, G. (2004) 'Marginalization of socio-scientific material in science-technology-society science curricula' In E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer. 215-231.

Hyman, L.; Lamb, J. and Bulmer, M. (2006) 'The Use of Pre-Existing Survey Questions: Implications for Data Quality', *Proceedings of Q2006: European Conference on Quality in Survey Statistics,*
Available: http://ec.europa.eu/eurostat/documents/64157/4374310/22-Use-of-pre-existing-survey-questions-implications-for-data-quality-2006.pdf/e953a39e-50be-40b3-910f-6c0d83f55ed4
[Accessed: 24th May 2017]

IBM Corp. (2017) *IBM SPSS Statistics for Windows,* Version 25.0. New York: IBM Corp.

Ilica, A. (2016) 'On John Dewey's Philosophy of Education and its impact on Contemporary Education' *Plus Education*, 14(1), 7-13.

Illingworth, S. M. & Roop, H. A. (2015) 'Developing Key Skills as a Science Communicator: Case Studies of Two Scientist-Led Outreach Programmes', *Geosciences*, 5, 2-14.

Inglis, G. H. (2014) 'The Actual and Potential Participation of Primary School Students at Parents' Evenings: A Challenge to the Established Order', *Improving Schools,* 17 (1): 30-40.

Italian Chamber of Commerce in the UK (nd) 'North West Economy: A brief overview.' Available: http://www.italchamind.eu/EN/pdf/pub_uk/Nortwest_Economy.pdf [Accessed 28th October 2016]

Ivie, R. and Langer Tesfaye, C. (2012) 'Women in Physics: A tale of limits' *Physics Today*, 65(2), 47-50.

Jack, B. M., Lin, H.-S. (2014) 'Igniting and sustaining interest among students who have grown cold toward science', *Science Education*, 98, 792–814.

James, L. E.; Laatsch, S.; Bosse, M. J. B.; Rider, R.; L. T & Anderson, C. J. (2006) 'Science Center Partnership: Outreach to Students and Teachers', *Rural Educator,* 28(1), 33-38.

Jasanoff, S. (2011) 'Constitutional moments in governing science and technology', *Science Engineering and Ethics*, 17(4), 621-638.

Jeffers A, T., Safferman, A.G., & Safferman, S. I. (2004) 'Understanding K–12 Engineering Outreach Programs'*, Journal of Professional Issues in Engineering Education and Practice,* 130(2), 95-108.

Jen, T. H., Lee, C. D., Chien, C. L., Hsu, Y. S., & Chien, K. M. (2013) 'Perceived social relationships and science learning outcomes for Taiwanese eighth graders: Structural equation modelling with a complex sampling consideration', *International Journal of Science and Mathematics Education*, *11*(3), 575–600.

Jenkins, E. W. (2004) 'School science, citizenship and the public understanding of science', In E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer. 13-20.

Jeynes, W. H. (2015) 'A Meta-Analysis on the Factors That Best Reduce the Achievement Gap', *Education and Urban Society*, 47(5), 523–554.

Jindal-Snape, D. And Miller, D. J. (2008) 'A challenge of living? Understanding the psycho-social process of the child during primary-secondary transition through resilience and self-esteem theories?', *Educational Psychology Review*, 20, 217-236.

Jobrack, B. (n.d.) 'The 5E Instructional Model Engage Explore Explain Evaluate EXTEND' [Online].
Available: http://eteamscc.com/wp-content/uploads/2015/07/Overview-of-5E-Instructional-Model.pdf
[Accessed 10th October 2019]

Joffe, H., & Yardley, L. (2004) 'Content and Thematic Analysis' In Marks, D.F. & Yardley, L. (Eds.), Research Methods for Clinical and Health Psychology. London: SAGE Publications, 56-66.

Joint Council for Qualifications (2017) *Examination Results'* [Online].
Available: https://www.jcq.org.uk/examination-results
[Accessed: 27th September 2017]

Johnson, R. B. and Onwuegbuzie, A. J. (2004) 'Mixed Methods research: a research paradigm whose time has come' *Educational Researcher,* 33(7), 14-26.

Joshi, A., Meza, J., Costa, S., Marcel, D., Perin, P., Trout, K. & Rayamajih, A. (2013) 'The Role of Information and Communication Technology in Community Outreach, Academic and Research Collaboration, and Education and Support Services (IT-CARES)' *Perspectives in Health Information Management*, Fall, 1-15.

Kang, J., Hense, J., Scheersoi, A. & Keinonen, T. (2019) 'Gender study on the relationships between science interest and future career perspectives', *International Journal of Science Education*, 41(1), 80-101.

Kaplan, A.,& Maehr, M. L.(2007) 'The contributions and prospects of goal orientation theory', *Educational Psychology Review,* 19, 141–184.

Katz, P., McGinnis, R. I., Hestness, E., Riedinger, K., Marbach-Ad, G., Dai, A., & Pease, R. (2011) 'Professional identity development of teacher candidates participating in an informal science education internship: A focus on drawings as evidence' *International Journal of Science Education*, 33, 1169–1197.

Kentish, B. (2017) *University tuition fees in England now the highest in the world, new analysis suggests* [The Independent online]
Available: https://www.independent.co.uk/news/education/university-tuition-fees-england-highest-world-compare-students-student-loan-calculator-a7654276.html
[Accessed 23rd June 2020]

Kerstetter, K. (2012) 'Insider, Outsider, or somewhere in between: The impact of researchers' identities on the community-based research process', *Journal of Rural Social Sciences*, 27(2), p. 99–117

Khatri, R. J. and Ozano, K. A. (2018) 'Reflexivity, positionality and power in cross-cultural participatory action research with research assistants in rural Cambodia', *Educational Action Research*. 26(2), 190-204

Kind, V. (2009) 'A Conflict in Your Head: An exploration of trainee science teachers' subject matter knowledge development and its impact on teacher self-confidence', *International Journal of Science Education,* 31(11), 1529-1562.

Kinnear, P. and Gray. C. (2004) *SPSS 12 made simple*, Hove and New York: Psychology Press.

Kitwood, T. M (1977) 'Values in adolescent life: towards a critical description', unpublished PhD dissertation, School of Education, University of Bradford.

Kitzinger, J. (1993) 'Understanding Aids: researching audience perceptions of acquired immune deficiency syndrome' in Eldridge, J. (ed.) *Getting the Message*, London: Routledge.

Koehler, B. G.; Park, L. Y. and Kaplan, L. J. (1999) 'Science for Kids Outreach Programs: College Students Teaching Science to Elementary School Students and Their Parents', *Journal of Chemical Education*, 76(11). 1505-1509.

Kress, G. Jewitt, C., Bourne, J., Franks, A., Hardcastle, J., Jones, K. & Reid, E. (2005) *English in urban classrooms*: *A Mulitmodal Perspective of Teaching and Learning*. London: Routledge Falmer.

Kronsnick, J. A. (1999) 'Survey research', *Annual review of psychology*, 50(1), 537-567.

Krosnick, J. A. & Presser, S. (2010) 'Question and questionnaire design'. In: Marsden, P. V. & Wright, J. D. (eds.) *Handbook of survey research*. (2nd edition). Bingley: Emerald Group Publishing Limited, 263-314.

Krueger, R. A. & Casey, M. A. (2014) *Focus groups: A practical guide for applied research*. Thousand Oaks: Sage.

Kruskal, W. H., & Wallis, W. A. (1952). 'Use of ranks in one-criterion variance analysis', *Journal of the American Statistical Association*, 47(260), 583-621.

Kuhn, T. (1962/1970). *The structure of scientific revolutions*. Illinois: University of Chicago Press.

Kuhn, T. S. (1996) *The Structure of Scientific Revolutions*. Chicago: The University of Chicago Press.

Kuppan, L. Munirah, S.K. Foong, S.K. and Yeung, A.S. (2010) 'On the Attitude of Secondary 1 Students towards Science', *International Conference on Physics Education 2009-IECP2009*, American Institute of Physics.

Kvale, S. (2008) *Doing interviews.* Thousand Oaks: Sage.

Laerd Statistics (2019) *Leard Statistics: SPSS Statistics and Tutorials and Statistical Guide* [Online.] Available: https://statistics.laerd.com
[Accessed 28th September 2019]

Laerd Statistics. (2019). *Testing for Normality using SPSS Statistics*. [Online].
Available: https://statistics.laerd.com/spss-tutorials/testing-for-normality-using-spss-statistics.php
[Accessed 2nd September 2019]

Lamanauskas, V. & Augienè, D. (2018) 'Scientific research activity organisation and improvement in a primary school', *Review of Science Mathematics & ICT Education,* 12(2), 5-21

Landry, J. P., Barnett, H. L., Chapman, D. L., & McCullough, R. (2019) 'Four Strategies for Driving a University Pre-College Computing Outreach Program', *Journal of Information Systems Education,* 30(3), 191–201.

Lapadat, J. C. & Lindsay, A. C. (1999) 'Transcription in research and practice: From standardization of technique to interpretive positioning', *Qualitative inquiry*, 5(1), 64- 86.

Larkin, D. B. (2016) 'Putting Physics First: Three Case Studies of High School Science Department and Course Sequence Reorganization', *School Science & Mathematics*, 116(4), 225–236.

Lave, J., & Wenger, E. (1991) *Situated learning: Legitimate peripheral participation.* Cambridge, England: Cambridge University Press.

Layder, D. (1998) *Sociological practice: Linking theory and social research*. London: Sage

Lee, J., Jo, H. & Choi, J. D. (2011) 'The organizations for space education and outreach programs in the Republic of Korea' *Acta Astronautica*. 69, 730–736.

Lavigne, G. L and Vallerant, R. J. (2007) 'A motivational model of persistence in science education: A self-determination theory approach', *European Journal of Psychology of Education* 22(3), 351-369.

Leach, J. And Scott, P. (2013) "Designing and evaluating science teaching sequences: An approach drawing upon the concept of learning demand and a social constructivist perspective on learning" In Scanlon, E. and Holliman, R. (Eds) *Medicating science learning though information and communications technology*, Oxon, Routledge.

LeCompte, M. and Preissle, J. (1993) *Ethnography and Qualitative Design in Educational Research* (2nd edition) London: Academic Press.

Lee, N. (2017) 'Powerhouse of cards? Understanding the 'Northern Powerhouse', *Regional Studies*, 51(3), 478-489.

Lee, O.; Maerten-Rivera, J.; Penfield, R. D.; LeRoy, L. and Secada, W. G. (2008) 'Science achievement of English language learners in urban elementary schools: Results of a first-year professional development intervention', *Journal of Research in Science Teaching*, 35, 31-52.

Leech, N. L. and Onwuegbuzie, A. J. (2002) 'A Call for Greater Use of Nonparametric Statistics' Paper presented at the Annual Meeting of the Mid-South Educational Research Association. Chattanooga, TN, November 6-8, 2002.

Leibham, M. B.; Alexander, J. K. and Johnson, K. E. (2013) 'Science Interests in Preschool Boys and Girls: Relations to Later Self-Concept and Science Achievement', *Science Education*, 97(4), 574–593.

Lemke, J. (2001) 'Articulating communities: sociocultural perspectives of science education' *Journal of research in Science Teaching*, 38, 296-316.

Lenhard, W. & Lenhard, A. (2016) *Calculation of Effect Sizes* [Online].
Available: https://www.psychometrica.de/effect_size.html
[Accessed 22nd August 2019].

Lent, R. W., Brown, S. D., & Hackett, G. (1994) 'Toward a unifying social cognitive theory of career and academic interest, choice, and performance', *Journal of Vocational Behavior*, 45(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (2002) 'Social cognitive career theory'. In Brown, D. (Ed.), *Career choice and development*. San Francisco, CA: Jossey-Bass. 255–311.

Leonardi, S., Lamb, H., Howe, P. & Choudhoury, A. (2017) 'State of Nation' Report of UK Primary Science Education, *Wellcome Trust* [Online].
Available: https://wellcome.org/sites/default/files/understanding-state-of-the-nation-report-of-uk-primary-science-education.pdf
[Accessed 13th September 2019]

Let's Talk Science. (2013).*Spotlight on science learning: The high cost of dropping science and math.* [Online].
Available: https://letstalkscience.ca/sites/default/files/2019-08/2013%20LTS_High%20Cost%20of%20Dropping%20STEM%20EN_0.pdf
[Accessed 16th April 2017]

Luke, A. Woods, A. and Weir, K. (2012) *Curriculum, Syllabus Design and Equity: A Primer and Model* [ProQuest Ebook Central Edition Online].
Available: http://ebookcentral.proquest.com/lib/ljmu/detail.action?docID=1020267
[Accessed 17th June 2018]

Likert, R. (1932) *A Technique for the Measurement of Attitudes*, New York: Columbia University Press.

Lincoln, Y. (2010) '"What a long, strange trip it's been…": Twenty-Five years of qualitative and new paradigm research', *Qualitative Inquiry*, 16, 3-9.

Lofland, J. (1971) *Analyzing Social Settings,* Belmont, CA: Wadsworth

Long, R.; Hubble, S. and Loft, P. (2020) Careers guidance in schools, colleges and universities. *House of Commons Libraries*: B*riefing Paper*. Number 07236 [Online].
Available: https://www.parliament.uk/commons-library
[Accessed 17 August 2020]

Lehmann, A. L. and Markowitz, D. (2007) 'Science Teachers' Perceived Benefits of an Out-of-

School Enrichment Programme: Identity Needs and University Affordances', *International Journal of Science Education.* 29(9), 1133-1161.

Lhussier, M., V, Carr, S. M. and Forster, N. (2015) 'A realist synthesis of the evidence on outreach programmes for health improvement of Traveller Communities' *Journal of Public Health*, 38(2), 125-132.

Liversidge, T. (2009) 'Creativity and Innovation in Science Teaching and Learning', In, Liversidge, T., Cochran, M., Kerfoot, B.& Thomas, J. (Eds.) *Teaching Science*, London: SAGE Publications Ltd.

Luke, A. (2012) Introduction-The Practical problem of Curriculum making IN: Luke, A, et al. *Curriculum, Syllabus Design and Equity*: *A Primer and Model,* [ProQuest Ebook Central Edition Online].
Available: http://ebookcentral.proquest.com/lib/ljmu/detail.action?docID=1020267.
[Accessed 4th August 2020]

Lyons, T. (2006) 'Different countries, same science classes: students' experiences of school science in their own words' *International Journal of Science Education*. 28, 591–613.

Luke, A. (2012) Introduction-The Practical problem of Curriculum making IN: Luke, Allan, et al. Curriculum, Syllabus Design and Equity: A Primer and Model, Taylor & Francis Group, 2012. ProQuest Ebook Central,
http://ebookcentral.proquest.com/lib/ljmu/detail.action?docID=1020267.
[Accessed 10th Oct 2019]

MacLean, L. M. (2017) *Cracking the Code: How to Get Women and Minorities into STEM Disciplines and Why We Must.* [ProQuest Ebook Central Edition Online].
Available: http://ebookcentral.proquest.com/lib/ljmu/detail.action?docID=4791046 .
[Accessed 17th March 2020]

Macorr Research Solutions Online (2016) Sample Size Methodology [Online]
Available: http://macorr.com/sample-size-methodology.htm
[Accessed 26th October 2016]

Maehr, M. L., & Zusho, A. (2009) 'Achievement goal theory: The past, present, and future' In K Wentzel & A. Wigfield (Eds.*), Handbook of motivation in school* . New York, NY: Routledge, 77–104.

Malachowski, A. (2010) *The New Pragmatism*, Montreal: McGill_Queens's University Press.

Mallaburn, A, Seton, L and Goodwin, M (2018) 'Chemistry: The essential spark for engagement'. *Education in Science*, 272, 26-27.

Maltese, A. V. and Robert, H. Tai (2010) 'Eyeballs in the Fridge: Sources of early interest in science' *International Journal of Science Education*, 35(2), 669-685.

Mangione, T. W. (1995) *Mail Surveys: Improving the Quality*. Thousand Oakes, CA: Sage.

Mann, H. B. and Whitney, D. R. (1947) 'On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other', *Annals of Mathematical Statistics*. 18 (1): 50–60.

Marchand, G. C. & Taasoobshirazi, G. (2013) 'Stereotype Threat and Women's Performance in Physics', *International Journal of Science Education*, 35 (18), 3050-3061.

Markowitz, D. G. (2004) 'Evaluation of the Long-Term Impact of a University High School Summer Science Program on Students, Interest and Perceived Abilities in Science', *Journal of Science Education & Technology*, 13(3), 395–408.

Marsh, H.W., Craven, R. G.,& Debus, R. (1991) 'Self-concepts of young children 5 to 8 years of age: Measurement and multidimensional structure' *Journal of Educational Psychology*, 83, 377 – 393.

Marshall, C. and Rossman, G. B. (2016) *Designing Qualitative Research* (Sixth Edition). Thousand Oakes, CA: Sage.

Martin, A. J., Beska, B. J., Wood, G., Wyatt, N., Codd, A., Vance, G., & Burford, B. (2018). 'Widening interest, widening participation: Factors influencing school students' aspirations to study medicine', *BMC Medical Education, 18*(1), 1-13.

McCrory, A. & Worthington, K. (2018) *Mastering primary science*. London: Bloomsbury

McLain, L. R. and Zimmerman, H. T. (2014) 'Prior Experiences Shaping Family Science Conversations at a Nature Center', *Science Education*, 98(6), 1009-1032.

McLellan, E., MacQueen, K. M. & Neidig, J. L. (2003) 'Beyond the qualitative interview: Data preparation and transcription', *Field Methods*, 15(1), 63-84.

McMahon, M. (2018) *Parent Involvement in the Schools -- Research Starters Education*, Ipswitch MA: EBSCO

Meisner, R. and Osborne, J. (2009) 'Engaging with interactive science exhibits: a study of children's activity and the value of experience for communicating science', in Holliman, R. Whitelegg, E. Scanlon, E. Smidt, S. and Thomas, J. (eds) *Investigating Science Communication in the Information Age: Implications for public engagement and popular media.* Milton Keynes: Open University Press. 86-102.

Mendick, H. (2006) *Masculinities in Mathematics*. Maidenhead: Open University Press.

Millar, R. And Osbourne, J. (Ed) (1998) *Beyond 2000*. London: Kings College School of Education,

Mintzes, J. J., Marcum, B., Messerschmidt-Yates, C., & Mark, A. (2013) 'Enhancing Self-Efficacy in Elementary Science Teaching With Professional Learning Communities', *Journal of Science Teacher Education*, *24*(7), 1201–1218. https://doi.org/10.1007/s10972-012-9320-1

Misher, E. G. (1991) 'Representing discourse: the rhetoric of transcription', *Journal of Narrative and Life History,* 1(4), 225-280.

Moote, J., Archer, L., DeWitt, J. and MacLeod, E. (2020) 'Science capital or STEM capital? Exploring relationships between science capital and technology, engineering, and maths aspirations and attitudes among young people aged 17/18', *Journal of Research in Science Teaching*, 57, 1228–1249

Morais, C., Arajo, J., & Sade, I. (2019) 'Awakening to chemistry through storytelling and practical activities: Middle school students interacting with pre-school children', *Chemistry Education Research and Practice,* 20(1), 302-315.

Morgan, D. L. (2014) 'Pragmatism as a Paradigm for Social Research' *Qualitative Inquiry,* 20(8), 1045–1053.

Morgan, D. L. and Krueger, R. A. (1993) 'When to use focus groups and why' in D. L. Morgan (eds) *Successful Focus Groups: Advancing the State of the Art*. Thousand Oaks, CA: Sage.

Morgan, P. L.; Farkas, G.; Hillemeier M. M. and Maczuga, S. (2016) 'Science Achievement Gaps Begin Very Early, Persist, and Are Largely Explained by Modifiable Factors', *Educational Researcher,* 45(1), 18–35.

Mufti, E. (2009) 'White working-class kids: Why are they failing?' In: Kassem, D. and Garratt, D. (Ed) *Exploring Key issues in Education*, London: Continuum International Publishing Group.

Mujtaba, T., & Reiss, M. (2013) 'Inequality in Experiences of Physics Education: Secondary School Girls' and Boys' Perceptions of their Physics Education and Intentions to Continue with Physics After the Age of 16'. *International Journal of Science Education*, 35 (11), 1824-1845.

Mujtaba, T., & Reiss, M. (2013a). 'Inequality in Experiences of Physics Education: Secondary School Girls' and Boys' Perceptions of their Physics Education and Intentions to Continue with Physics After the Age of 16'. *International Journal of Science Education*, 1-22.

Mujtaba, T and Resiss, M. (2013b) 'What Sort of Girl Wants to Study Physics After the Age of 16? Findings from a Large-scale UK Survey' *International Journal of Science Education*, 35(17), 2979-2998

Muller, C. L., Roberts, S., Wilson, R. C., Remedios, J. J., Illingworth, S., Graves, R. & Desai, A. (2013) 'The Blue Marble: a model for primary school STEM outreach', *Physics Education*. 48(2), 176-183.

Murcia, K., & Pepper, C. (2018) 'Evaluating the social impact of a science centre's STEM professional learning strategies for teachers', *Issues in Educational Research*, 28(2), 438–452.

Murphy, P. (2011) 'The Nature of individual thought', In, *Block 2, update 4, SEH806 Contemporary issues in science learning,* Milton Keynes: The Open University.

Murphy, C. Ambusaidi, A. And Beggs, J. (2006) 'Middle East meets Middle West: Comparing children's attitudes towards school science', *International Journal of Science Education Journal,* 14, 405-422.

Murphy, C., & Beggs, J. (2001) 'Students' attitudes, perceptions and understanding of primary science: Comparisons between Northern Irish and English schools'. *Paper presented at the BERA conference*, University of Leeds, UK.

Murphy, P. Scanlon, E. and Lunn, S. (2009) 'Learning and Understanding Science: Issues and Debates', *Block 2 of SEH806 Contemporary issues in science learning*, Milton Keynes: The Open University.

N8 research partnership (2017) *N8 Forward Strategy 2017* [Online].
Available: http://www.n8research.org.uk/view/7134/Strategy-2017.pdf
[Accessed: 25th September 2017]

Nachar, N. (2008) 'Mann-Whitney U: A test for assessing whether two independent samples come from the same distribution', T*utorials in Quantitative Methods for Psychology*, 4(1), 13-20.

Nagayama, Y. and Hasegawa, M. (2014) 'Nursing care process for releasing psychiatric inpatients from long-term seclusion in Japan: Modified grounded theory approach', *Nursing and Health Sciences.* 16, 284-290.

McCrone, T., Sims, D. Association of Employment and Learning Providors (AELP), Gladding, C. (2016) *Providing for the Future: Providers' views on Apprenticeship Reform.* Berkshire: National Foundation for Educational Research (NFER).

National Science Foundation (2008) *Comments on outreach from the mathematical and physical science advisory committee, [Online].*
Available: https://nsf.gov/attachments/110624/public/CommentsonOutreach.pdf
[Accessed 13th January 2017]

Natural Sciences and Engineering Research Council of Canada (2004) *Centres for Research in Youth, Science Teaching and Learning (CRYSTAL) Mid-term review* available [Online]
Available: http://www.nserc-crsng.gc.ca/_doc/Reports-Rapports/Evaluations/CRYSTAL_Mid-term_Review_Report_eng.pdf
[Accessed 13th January 2017]

Needham, R. (2014) 'The contribution of practical work to the science curriculum', *School Science Review,* 95(352), 63-69.

New Zealand Office of the Prime Minister's Science Advisory Committee. (2011*) Looking Ahead: Science Education for the twenty first century.* Wellington: New Zealand.

Newell, A. D., Zientek, L. R., Tharp, B. Z., Vogt, G. L. & Moreno, N. P. (2015) 'Students' Attitudes Toward Science as Predictors of Gains on Student Content Knowledge: Benefits of an After-School Program',. *School Science & Mathematics,* 115(5), 216-226.

National Foundation for Educational Research (NFER) (2018) *Teacher Workforce Dynamics in England* [Online]. Available:
https://www.nfer.ac.uk/media/3111/teacher_workforce_dynamics_in_england_final_report.pdf
[Accessed 17th October 2019]

Noaparast K.B. (2015) 'Neo-pragmatist Philosophy of Education'. In: Peters M. (eds) *Encyclopedia of Educational Philosophy and Theory*. Springer: Singapore.

Nuffield Foundation (n.d.) *Welcome to Twenty First Century Science'*(nd) [Online]. Available:http://www.nuffieldfoundation.org/twenty-first-century-science
[Accessed 5th October 2016].

NVivo (2017) *Qualitative data analysis Software, Version 10,* QSR International Pty Ltd. (advised: NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 11)

OCR (2011) *Science Summary Brochure*, Cambridge OCR. [Online].
Available: http://www.ocr.org.uk/images/77407-gcse-sciences-from-2011-summary-brochure.pdf
[Accessed 3rd October 2016]

Ofqual (2015) *Assessment of Practical Work in New Science GCSEs – Summary* [Online].
Available:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408513/2015-03-03-assessment-of-practical-work-in-new-science-gcses-summary.pdf
[Accessed 10th April 2018]

Ofsted (2013) *Maintaining Curiosity: A survey into science education in schools* [Online].
Available:www.gov.uk/government/uploads/system/uploads/attachment_data/file/379164/Maintaining_20curiosity_20a_20survey_20into_20science_20education_20in_20schools.pdf
[Accessed: 25th September 2017]

Ofsted (2013a) *Going in the Right Direction? Careers Guidance in Schools from September 2012.* [Online].
Available: www.ofsted.gov.uk/resources/going-rightdirection-careers-guidance-schools-september-2012.
[Accessed 20th April 2020]

Ofsted (2013b) *The Unlucky Child.* [Online].
Available: https://dera.ioe.ac.uk/18984/1/Annual%20Report%201213%20-%20The%20unlucky%20child%20-%20HMCI%20speech.pdf
[Accessed 10th May 2019]

Ofsted (2018) *Careers guidance and access for education and training providers* [Online]
Available:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/748474/181008_schools_statutory_guidance_final.pdf.
[Accessed: 23rd June 2021]

Olafsson, K., Ostgaard, N., & Tanskanen, E. (2009) 'The Space Science Suitcase—Instruments for Exploring Near-Earth Space from the Classroom', *Earth, Moon & Planet,* 104, 73–75.

Onwuegbuzie, A. J. (2012) 'Introduction: Putting the MIXED back into quantitative and qualitative research in educational research and beyond: Moving toward the radical middle', *International Journal of Multiple Research Approaches*, 6(3), 192–219.

Onwuegbuzie, A, & Leech, N. (2005) 'On becoming a pragmatic researcher: The importance of combining quantitative and qualitative research methodologies', *International Journal of Social Research Methodology*, 8(5), 375-387.

Oppermann, E., Brunner, M., Eccles, J., & Anders, Y. (2018) 'Uncovering young children's motivational beliefs about learning science', *Journal of Research in Science Teaching,* 55(3), 399-421.

Orton, J. D. (1997) 'From Inductive to Iterative Grounded Theory: Zipping the Gap between Process Theory and Process Data', *Scandinavian Journal of Management,* 13(4), 419-438.

Osborne, J. (2015) 'Practical work in science: Misunderstood and badly used?', *School Science Review,* 96(357), 16-24.

Osbourn, J.; Simon, S. and Collins, S. (2003) 'Attitudes towards science: A review of literature and its implications' *International Journal of Science Education*, 25(9), 1049-1079.

Oshima, J., Oshima, R., Murayama, I., Inagaki, S., Takenaka,M., Nakayama, H. & Yamaguchi, E. (2004) 'Design experiments in Japanese elementary science education with computer support for collaborative learning: hypothesis testing and collaborative construction', *International Journal of Science Education*. 26(10), 1199–1221.

Pallant, J. (2013) *A step by step guide to data analysis using IBM SPSS: SPSS Survival Manual,* (5th edition), Berkshire, Open University press.

Partridge, J., Brustad, R., Babkes Stellinoin, M. & Horn, M. (2013) 'Theoretical perspectives: Eccles' expectancy-value theory', In Partridge, J., Brustad, R. and Babkes Stellinoin, M. & Horn, T.S.(ed) *Advances in Sport Psychology*, (3rd Edition), Champaign: HumanKinetics, 269–292.

Patterson, M. M., Kravchenko, N., Chen-Bouck, L., & Kelley, J. A. (2016) 'General and domain-specific beliefs about intelligence, ability, and effort among preservice and practicing teachers', *Teaching and Teacher Education,* 59, 180-190.

Patton, M. Q. (1990) *Qualitative evaluation and research methods* (2nd Edition). Newbury Park, CA: Sage.

Pavlov, I. P. (1897/1902). *The work of the digestive glands*. London: Griffin.

Peacock, G., Sharp, J., Johnsey, R. & Wright, D. (2014/2017*) Primary Science Knowledge and Understanding*. (7th/8th ed) Exeter: Learning Matters.

Peacock, A. (2010) "The Emergence of Primary Science" *In Block 1 Interviews DVD-ROM. SEH806 Contemporary Issues in Science Learning*, Milton Keynes, The Open University.

Peacock, G. Sharp, J. Johnsey, R. And Wright, D. (2009) *Primary Science: Knowledge and Understanding*, (4th Edition), Learning Matters Ltd, Exeter.

Pearson (nd) 'Conversion Table of USA Grades to School Years' [Online]. Available: https://www.pearsonclinical.co.uk/Sitedownloads/Miscpdfs/Gradetoage.pdf [Accessed 28th August 2019]

Perera, L. D. H. (2014) 'Parents' Attitudes towards Science and their Children's Science Achievement', *International Journal of Science Education*, 36:18, 3021-3041.QCA (2007) *Science curriculum,* [Online].
Available*:* www.qca.co.uk/curriculum
[Accessed 16th November 2016].

Pettigrew, S. F. (2000) 'Ethnography and grounded theory: a happy marriage?', *Advances in Consumer Research*, 27, 229-243.

Phillips, D. C. (1995) 'The Good, the Bad, and the Ugly: The Many Faces of Constructivism', *Extracts from Educational Researcher*, 24(7), 5-12.Phyliss, K. McGinnis, J. R., Hestness, E.,

Prince, M. (2004) 'Does Active Learning Work? A Review of the Research' *Journal of Egineering Education*, 93, 223-231.

Quinn, D. M. and Cooc, N. (2015) 'Science Achievement Gaps by Gender and Race/Ethnicity in Elementary and Middle School: Trends and Predictors', *Educational Researcher*, 44(6), 336–346.

Random.Org [Online] *Random number generator* [Online].
Available: https://www.random.org/
[Accessed 12th October 2016]

Radom, R., & Gammons, R. W. (2014) 'Teaching Information Evaluation with the Five Ws'. *Reference & User Services Quarterly*, 53(4), 334–347. https://doi.org/10.5860/rusq.53n4.334

Ralston, P. A. S., Hieb, J. L., & Rivoli, G. (2013) 'Partnerships and Experience in Building STEM Pipelines' *Journal of Professional Issues in Engineering Education & Practice*, 139(2), 156–162. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000138

Reichertz, J. (2010) 'Abductions: The Logic of Discovery of Grounded Theory', *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research,* 11(1), Art 13.

Reichertz, J. (2019) 'Abductions: The Logic of Discovery of Grounded Theory-An Updated Review' In Bryant, A. and Charmaz, C. (eds.) *The SAGE Handbook of current developments in Grounded Theory*, London: SAGE Publications Ltd. 259-281.

Reidun, T. (2014) 'Balancing Ethics and Quality in Educational Research—the Ethical Matrix Method', *Scandinavian Journal of Educational Research*, 58(6), 678-694.

Reiss, M. J. & Mujtaba, T. (2017) 'Should we embed careers education in STEM lessons?', *The Curriculum Journal,* 28(1), 137-150.

Reiss, MJ and Abrahams, I (2015) 'The assessment of practical skills', *School Science Review,* 357(96), 40-44

Renninger, K. A. (1992) 'Individual interest and development: Implications for theory and practice' In Renninger, K.A. , Hidi, S. & Krapp, A. (Eds.), The role of interest in learning and development, Hillsdale, NJ: Erlbaum. 361 – 396.

Research Councils UK. (2008). *Review of UK physics*. Swindon: Research Councils UK. [Online]. Available: http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/reviews/physics/review.pdf. [Accessed 31st October 2017]

Research Methodology (2016) *Purposive sampling* [Online].
Available online at http://research-methodology.net/sampling-in-primary-data-collection/purposive-sampling
[Accessed 14th October 2016]

Riedinger, K., Marbach-Ad, G. Dai, A. and Pease, R. (2011) 'Professional Identity Development of Teacher Candidates Participating in an Informal Science Education Internship: A focus on drawings as evidence' *International Journal of Science Education*, 33 (9), 1169-1197.

Rich, J (2012) *Five reasons that UK universities cannot do outreach on their own* [The Guardian Online]
Available at https://www.theguardian.com/higher-education-network/blog/2012/sep/24/university-school-outreach-support-partners
[Accessed 1st June 2018]

Rodd. M. Reiss, M. & Mujtaba, T. (2013) 'Undergraduates talk about their choice to study physics at university: what was key to their participation?', *Research in Science & Technological Education*, 31(2), 153-167.

Rodriguez, R., & Elbaum, B. (2014) 'The Role of Student-Teacher Ratio in Parents' Perceptions of Schools' Engagement Efforts', *The Journal of Educational Research,* 107(1), 69-80.

Rogers, S. (2020) 'Student Finance and Funding' *Complete University Guide* [Online].
Available: https://www.thecompleteuniversityguide.co.uk/student-advice/finance/student-finance-and-funding
[Accessed 23rd June 2020]

Rorty, R. (1967). *The Linguistic Turn: Recent Essays in Philosophical Method.* Chicago and London: The University of Chicago Press.

Rorty, R. (1979). *Philosophy and the mirror of nature.* Princeton N.J.: Princeton University Press.

Rorty, R. (1982). 'Method, social science, and social hope'. In *Consequences of pragmatism.* Minneapolis: University of Minnesota Press.

Rorty, R. (1996). *Objectivity, Truth, and Relativism*. New York, NY: Cambridge University Press.

Rorty, R. (1999). *Philosophy and social hope.* Harmondsworth: Penguin.

Royal Institute (2017) *About the Christmas Lectures* [Online].
Available: http://www.rigb.org/christmas-lectures/about
[Accessed 10th January 2018]

Royal Society (1985) *The Public understanding of science*. London: The Royal Society

Royal Society (2004) *Taking a leading role: A good practice guide* (Scientist survey). London, The Royal Society.

Royal Society of Chemistry (2014) *Inspiring, engaging and expert: the formula for world-class science and chemistry education* [Online].
Available at: http://www.rsc.org/campaigning-outreach/campaigning/specialist-teaching/
[Accessed 31st October 2016]

Royal Society of Chemistry (2016) *Campaigning and Outreach for educators* [Online].
Available: http://www.rsc.org/campaigning-outreach/outreach/educators/
[Accessed 21st November 2016]

Royal Society of Chemistry (2020) *Is Chemistry Accessible to All* [Online].
Available: https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-is-chemistry-accessible-for-all.pdf
[Accessed 25th January 2021]

Royal Society of Chemistry (RSC) (n.d.) *Chemistry for All* [Online].
Available: https://www.rsc.org/campaigning-outreach/outreach/scientists/chemistry-for-all
[Accessed 20th September 2020]

Royal Society of Chemistry (RSC) (n.d.a) *Careers Guidance* [Online].
Available: https://www.rsc.org/campaigning-outreach/outreach/future-of-career-guidance/
[Accessed 25th January 2021]

Royal Society; Research Council UK and Wellcome Trust (2006) *Factors affecting science communication; a survey of scientists and engineers*, London; The Royal Society

Ryan, R. M., & Deci, E. L. (2000) 'Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being', *American psychologist,* 55(1), 68.

Ryan, R. M. and Deci, E. L. (2017) *Self-Determination Theory Basic Psychological Needs in Motivation, Development and Wellness* New York: Guildford Press.

Ryder, J. (2015). Being professional: Accountability and authority in teachers' responses to science curriculum reform. Studies in Science Education, 51(1), 87–120

Rylander A (2012) 'Pragmatism and Design Research – An Overview'. *Ingår i Designfakultetens serie kunskapssammanställningar.* [Online].
Available:
http://www.designfakulteten.kth.se/sites/default/files/designfpragdesignrapport_18.4.pdf
[Accessed 31st July 2017]

Saab, B. J. (2010) 'Engaging the Clutch of the Science Communication Continuum – Shifting Science Outreach into High Gear', *Hypothesis,* 8(1), 1-7.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012) 'Stability and volatility of STEM career interest in high school: A gender study', *Science Education*, 96, 411–427.

Sadler, T. D. (2011) *Scoio-scientific Issues in the Classroom: Teaching. Learning and Research*, The Netherlands: Springer.

Sadler, K., Eliam, F. Bigger, S. W. and Barry, F. (2018) 'University-led STEM outreach programs: purposes, impacts, stakeholder needs and institutional support at nine Australian Universities', *Studies in Higher Education,* 43(3), 586-599.

Sanford Laboratory (2017). *Education Impact* [Online].
Available: https://www.sanfordlab.org/feature/education-impact
[Accessed 11th February 2017]

Sansone, A. (2018) 'Reframing science learning and teaching: A communities of practice approach', *Middle School Journal*, 49(2), 16–23.

Scalon, E. Smidt, S and Thomas, J. (2009) *Investigating Science Communication in the Information Age: Theorising and Professional Practices*. Milton Keynes: Open University Press.

Scanlon, E. *et al* (eds) *Reconsidering Science learning*, London, Routledge Falmer. pg. 21-36.

Schilpzand, E.; Sciberras, E.; Efron, D.; Anderson, V. and Nicholson, J. M. (2015) 'Improving Survey Response Rates from Parents in School-Based Research Using a Multi-Level Approach', *PLoS ONE*, 10(5), 1-11.

Schoon, I. (2001) 'Teenage job aspirations and career attainment in adulthood: A 17-year follow-up study of teenagers who aspired to become scientists, health professionals, or engineers', *International Journal of Behavioral Development*, 25(2), 124–132.

Schoon, I., & Parsons, S. (2002) 'Teenage aspirations for future careers and occupational outcomes', *Journal of Vocational Behavior*, 60(2), 262-288.

Schoon, I and Polek, E. (2011) 'Teenage career aspirations and adult career attainment: the role of gender, social background and general cognitive ability', *International Journal of Behavioral Development*, 35(3), 210-217.

Schoon, I.; Ross, A. and Martin, P. (2007) Science related careers: aspirations and outcomes in two British cohort studies. *Equal Opportunities International*, 26 (2), 129 – 143. DOI: 10.12691/education-6-8-21

Schulz R.M. (2014) Philosophy of Education and Science Education: A Vital but Underdeveloped Relationship. In: Matthews M. (eds) International Handbook of Research in History, Philosophy and Science Teaching. Dordrecht: Springer. 1259-1316.

Schurz, G. (2008). 'Patterns of abduction', *Synthese*, 164, 201–234.
Science and me (nd) [Online]. Available: http://www.scienceandme.org/
[Accessed 1st May 2019]

Science and Technology Committee (2017) 'Industrial Strategy: science and STEM skills' *Parliament UK* [Online].
Available:https://publications.parliament.uk/pa/cm201617/cmselect/cmsctech/991/99102.htm
[Accessed 27th July 2020]

Scientists in Schools (SiS) (n.d.). *Scientists in Schools* [Online].
Available: http://www.scientistsinschool.ca
[Accessed 10th January 2017]

Scotland, J. (2012) 'Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms', *English Language Teaching*, 5(9), 9–16.

Scull, S. & Cuthill, M. (2010) 'Engaged outreach: using community engagement to facilitate access to higher education for people from low socio-economic backgrounds', *Higher Education Research & Development,* 29(1), 59-74.

See B. H., Gorard, S. & Torgerson, C. (2012) 'Promoting post-16 participation of ethnic minority students from disadvantaged backgrounds: a systematic review of the most promising interventions', *Research in Post-Compulsory Education*, 17(4), 409-422

See, B. H. & Gorard, S. (2015) 'The role of parents in young people's education—a critical review of the causal evidence', *Oxford Review of Education*, 41(3), 346-366.

Segue Technologies INC (2019) 'Waterfall V Agile Methodology [Online].
Available: https://www.seguetech.com/waterfall-vs-agile-methodology/
[Accesses 3rd October 2019]

Serrett, N., C. Harrison, C. Correia, and J. Harding. (2016) 'Primary Teachers' Understanding of Science Inquiry: Influences on their Teaching and Formative Assessment Practice' *ESERA Conference 2015*.

Senler, B. (2016) 'Pre-service science teachers' self-efficacy: The role of attitude, anxiety and locus of control', *Australian Journal of Education*, 60(1), 26-41.
Seton L, Mallaburn A, Goodwin M. (2018) 'Research Focus: Nurturing socio-economically challenged learners' curiosity in chemistry', *Education in Science*, 272(1), 28-29.

Sewry, J.; Glover, S.; Harrison, T.; Shallcross, D. and Ngcoza, K. (2014) 'Offering Community Engagement Activities To Increase Chemistry Knowledge and Confidence for Teachers and Students', *Journal of Chemical Education*, 91(10), 1611-1617.

Shallcross, D. E. and Harrison T. G. (2007) 'A secondary School Teacher Fellow within a university chemistry department: the answer to problems of recruitment and transition from secondary school to University and subsequent retention?', *Chemistry Education Research and Practice*, 8(1), 101-104.

Shallcross, D. E., Harrison, T. G., Obey, T. M., Croker, S. J. & Norman, N. C. (2013) 'Outreach within the Bristol ChemLabS CETL (Centre for Excellence in Teaching and Learning', *Higher Education Studies, 3*(1), 39-49.

Shanahan, M.; Pedretti, E.; DeCoito, I. & Baker, J. (2011) 'Exploring the Responses of underrepresented Students in Science to an Elementary Classroom Outreach program. School Science and Mathematics', 111(4), 131-142.

Shapiro, S. S., & Wilk, M. B. (1965) 'An analysis of variance test for normality (complete samples)', *Biometrika*, 52 (3&4), 591-611.

Shaw, A. J., Harrison, T. G. & Shallcross, D. E. (2010) 'What value has Chemistry outreach by a University department to secondary schools? Teacher perceptions of Bristol ChemLabs outreach events', *Acta Didactica Napocensia*. 3(3), 15-23.

Sheldrake, R. (2016) 'Students' intentions towards studying science at upper-secondary school: the differential effects of under-confidence and over-confidence', *International Journal of Science Education*, 38(8), 1256-1277.

Shirazi, S. (2017) 'Student experience of school science'*, International Journal of Science Education*, 39(14), 1891-1912,

Shumow, L., Schmidt, J. A., & Zaleski, D. J. (2013) 'Multiple perspectives on student learning, engagement, and motivation in high school biology labs', *The High School Journal*, 96(3), 232–252.

Simpkins, S. D. (2005) 'Parents' Socializing Behavior and Children's Participation in Math, Science, and Computer Out-of-school Activities', *Applied Developmental Science.* 9(1), 14.

Singh, A., Gupta, A., Gulvady, R., Mhamane, A., & Saunders, T. (2015) 'Doing is understanding: Science fun in India', *Science in School*, 34, 45-51.

Skelton, C. and Gorard, S. (2011) 'Education, education, education: new government, new policies?', *Educational Review*, 63(4), 391-394.

Skinner, B.F. (1957) *Verbal Learning.* New York: Appleton-Century-Crofts.

Smaill, C. R. (2010) 'The Implementation and Evaluation of a University-Based Outreach Laboratory Program', *Electrical Engineering IEEE Transactions on Education*. 53(1), 12-17.

Smidt, S. Scanlon, E. and Holliman, R. (2009) 'Communicating science in the information age: an introduction', Block 1 of SEH804 *Communicating Science in the Information Age*. Milton Keynes: The Open University.

Smith, E. (2010) 'Is there a crisis in school science education in the UK?' *Educational Review,* 62(2), 189-202.

Smith, J. L., Brown, E. R., Thoman, D. B. and Deemer, E. D. (2015) 'Losing its expected communal value: how stereotype threat undermines women's identity as research scientists', *Sociology and Psychology Education,* 18(1), 443-466.

Smith, M. J. (2008) 'Four Steps to a Paradigm Shift: Employing Critical Perspectives to Improve Outreach to Low-SES African-American and Latino Students and Their Parents', *Journal of College Admissions*, 201(1), 17-23.

Smith, T. (2018) 'Qualitative & Quantitative Research', Qualitative & Quantitative Research' *Research Starters Education* [Onine].
Available:http://search.ebscohost.com/login.aspx?direct=true&db=e0h&AN=31962646&site=ehost-live
[Accessed: 5 August 2020]

Spearman, C. (1910) *'Correlation calculated with faulty data', British Journal of Psychology,* 3, 271-295

Spradley, J. (1979) *The Ethnographic Interview.* Fort Worth*,* TX: Harcourt Brace Jovanovich.

Social Mobility Commission (2017) *Low income pupils' progress at secondary school* [Online].
Available:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/594363/Progress_at_Secondary_School_report_final.pdf
[Accessed 30th June 2019]

Social Mobility Commission (2020) *The Long Shadow of Deprivation-Differences in opportunities across England* [Online].
Available:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/923623/SMC_Long_shadow_of_deprivation_MAIN_REPORT_Accessible.pdf
[Accessed 29th January 2021]

Soliman, J. and Kan, M. (2004) 'Grounded Theory and NVivo: Wars and Wins' *International Conference on Qualitative Research in IT & IT in Qualitativ eResearch* 24-26 November., Australia. Hosted by the Institute for Integrated and Intelligent Systems, Griffith University.

Steele, C. M., & Aronson, J. (1995) 'Stereotype threat and the intellectual test performance of African Americans', *Journal of Personality and Social Psychology*, 69(5), 797-811.

Strauss, A. L. (1987) *Qualitative Analysis for Social Scientists*. Cambridge: Cambridge University Press.
Strauss, A. L. and Corbin, J. (1990) *Basics of Qualitative Research,* Newbury Park, CA: SAGE.

Strømsholm, B. (2011, October) 'Polar Research in the Classroom, after the IPY' In Ouwenhand, L. (Ed) *Proceedings of the 20th Symposium on European Rocket and Balloon Programmes and Related Research. ESA SP-700 ESA Communications ESTEC*, Noordwijk, The Netherlands. 219-222

Stutchbury, K. (2011) 'The Nature of Science', Block 1, update 1, SEH806 *Contemporary issues in science learning,* Milton Keynes: The Open University.

Stutchbury, K. Banks, F and Thomas, J. (2011) '21st Century Science and new GCSE specifications", Block 1, update 1, SEH806 *Contemporary issues in science learning,* Milton Keynes: The Open University.

Super, D. E. (1980) ‘A life-span, life-space, approach to career development’, *Journal of Vocational Behavior*, 16, 282–298.

Suri, H. (2014) *Towards Methodologically Inclusive Research Syntheses*. Oxon: Routledge.

Swants, M. (1996) ‘A personal position paper on participatory research: personal quest for living knowledge’, *Qualitative Inquiry*, 2(1), 120-136.

Szteinberg, G.; Balicki, S.; Banks, G.; Clinchot, M.; Cullipher, S.; Huie, R.; Lambertz, J.; Lewis, R.; Ngai, C.; Weinrich, M.; Talanquer, V. and Sevian, H. (2014) 'Collaborative Professional Development in Chemistry Education Research: Bridging the Gap between Research and Practice', *Journal Of Chemical Education*, 91(9), 1401-1408.

Tafreshi, B. (2009) ‘Popularising astronomy in Iran’. *Proceedings of the International Astronomical Union. 5* (S260), 754-757.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006) ‘Career choice: Planning early for careers in science’, *Science,* 312(5777), 1143–1144.

Tashakkori, A., & Teddlie, C. (2010) ‘Overview of contemporary issues in mixed methods research’. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods research for the social & behavioral sciences.* 2nd Edition. Thousand Oaks, CA: SAGE. 1-44

Taylor, R. C. (2015) ‘Using the theory of planned behaviour to understand students’ subject choices in post-compulsory education’, *Research Papers in Education*, 30(2), 214-231.

Taylor, S. J., Bogdan, R. and DeVault, M. L. (2015) *Introduction to qualitative research methods: a guidebook and resource,* Hoboken, New Jersey: John Wiley & Sons.

Tepper-Jacob, R. (2011) ‘An Experiment to Test the Feasibility and Quality of Web-based Questionnaires of Teachers’, *Education Review*, 35(1), 40-70.

Teusner, A. (2016) ‘Insider Research, validity issues, and the OHS professional: one person’s journey’, *International Journal of Social Research methodology,* 19(1), 85-96.

The Gatsby Foundation (2017) ‘Good Practical Science’ [Online]
Available: www.gatsby.org.uk/GoodPracticalScience
[Accessed 27th July 2020]

Thomas, C. L. (2012) ‘Assessing High School Students Learning on Science Outreach Lab Activities’, *Journal of Chemical Education,* 89(10), 1259-1263.

Thomas, J. And Banks, F. (2009) ‘Science Education: problems of definition and delivery’, Block 1 of SEH806 *Contemporary issues in science learning*, Milton Keynes: The Open University.

Thompson, M. (1999) *Foreign Affaires: A Sociological Exploration of Holiday Romance* PhD Thesis, Cardiff University.

Thornberg, R. (2012) 'Informed Grounded Theory', *Scandinavian Journal of Educational Research*, 56(3). 243-259.

Thornberg, R. and Charmaz, K. (2012) 'Grounded Theory' In. S Lapan, M. Quartoroli and F. Riemer (Eds): *Qualitative research: An introduction to methods and designs*. San Francisco: Jossey-Bass. 41-67

Tobin, K. (2004) 'Cultural Perspectives on the teaching and learning of science' n E. Scanlon, P. Murphy, J. Thomas & E. Whitelegg (Eds.), *Reconsidering science learning*, New York: Routledge Falmer. 176-194.

Toplis, R. Golabek, C. And Cleaves, A. (2005) 'Implementing a new science National Curriculum for England: how trainee teachers see the How Science Works strand in schools', *The Curriculum Journal,* 21(1), 65-76.

Trends in International Mathematics and Science Study (TIMSS) (2007) *Highlights from the trends in international mathematics and science study* [Online].
Available: http://nces.ed.gov/timss/results07.asp
[Accessed 19th May 2019].

Tuah, J., Harrison, T.G. & Shallcross, D.E. (2009) 'The Advantages Perceived by School Teachers in Engaging Their Students in University-Based Chemistry Outreach Activities', *Acta Didactica Napocensia*, 2(3), 31-44.

Tuckett, A. G. (2005) 'Applying thematic analysis theory to practice: A researcher's experience', *Contemporary Nurse*, 19(1-2), 75-87.

Türk, U. (2019) 'Socio-Economic Determinants of Student Mobility and Inequality of Access to Higher Education in Italy', *Networks & Spatial Economics,* 19(1), 125-149.

Tymms, P. Bolden, D. And Merrel, C. (2009) 'Science in English primary schools: trends in attainment, attitudes and approaches' In Wellcome Trust (2009) *Perspectives in Education: primary science.* Issue 1. London, Education.

Tweed, A., & Charmaz, K. (2011) 'Grounded Theory Methods For Mental Health Practitioners'. In Harper, D., & Thompson, A. R. (Eds.). *Qualitative Research Methods in Mental Health And Psychotherapy: A Guide For Students And Practitioners.* Chichester: John Wiley & Sons. 131-146

UKRI (2019) 'UKRI Vision for Public Engagement' available online at
https://www.ukri.org/files/per/ukri-vision-for-public-engagement-pdf/
Accessed on 24th June 2020

U. S. Department of Education (2004) *No Child Left Behind* [Online].
Available: https://www2.ed.gov/nclb/overview/intro/guide/guide.pdf
[Accessed 15th April 2020]

University of York (n.d.) *Working scientifically in the twenty first century* [Online].
Available:www.york.ac.uk/education/research/uyseg/projects/twentyfirstcenturyscience/workingscientificallyintwentyfirstcenturyscience
[Accessed 11th December 2016]

Urdan, T. C., & Maehr, M. L. (1995) 'Beyond a two-goal theory of motivation and achievement: A case for social goals. *Review of Educational Research'*, 65(3), 213–243.

Urdan, T., & Schoenfelder, E. (2006) 'Classroom effects on student motivation: Goal structures, social relationships, and competence beliefs', *Journal of School Psychology*, 44, 331–349.

Urquhart, C. (2013). *Grounded theory for qualitative research*, London: SAGE Publications Ltd

Urquhart, C. (2019) 'Grounded Theory's Best Kept Secret: The Ability to Build Theory' In Bryant, A. and Charmaz, C. (eds.) *The SAGE Handbook of current developments in Grounded Theory*, London: SAGE Publications Ltd. 89-106.

Van den Hurk, A.; Meelissen, M. and Van Langen, A. (2019) 'Interventions in education to prevent STEM pipeline leakage', *International Journal of Science Education,* 41:2, 150-164.

Van Est, R. (2011). The Broad Challenge of Public Engagement in Science Commentary on: "Constitutional Moments in Governing Science and Technology". *Science Engineering and Ethics*. 17(4), 639-648.

Van-Dijk, E. M. (2011) 'Portraying real science in science communication', *Science Education,* 95(1), 1086–1100

Vennix, J., den Brok, P., & Taconis, R. (2017) 'Perceptions of STEM-based outreach learning activities in secondary education', *Learning Environments Research*, 20(1), 21–46.

Vennix, J., Den Brok, P., & Taconis, R. (2018) 'Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM?', *International Journal of Science Education, 40*(11), 1263-1283.

Vincent, B. B. (2014) 'The politics of buzzwords at the interface of technoscience, market and society: The case of 'public engagement in science', *Public Understanding of Science*. 23(3), 238–253.

Vondraceck, F. W., Lerner, R. M., & Schulenberg, J. E. (1986) *Career development: A life-span developmental approach*. Hillsdale, NJ: Erlbaum.

Vondracek F.W., and Porfeli E.J. (2008) 'Social Contexts for Career Guidance throughout the World. Developmental-Contextual Perspectives on Career across the Lifespan'. In: Athanasou J.A., Van Esbroeck R. (eds) *International Handbook of Career Guidance*. Dordrecht: Springer.

VSVS (2017) *VSVS at a glance* [Online].
Available: https://studentorg.vanderbilt.edu/vsvs
[Accessed 15th May 2018]

Vygotsky, L. S. (1962) 'Thought and Language,' In Hanfmann, E. and Vakar, G. (Eds and Translator.) Cambridge MA: Cambridge University Press

Vygotsky, L. S. (1978) *Mind in Society: the development of higher mental processes*. Cambridge: Harvard University Press.

Vygotsky, L. S. (1987) 'The Collected Works of L. S. Vygotsky'. In Rieber, R. W. and Carton, A. S. (Eds. And Translator)) *Problems of General Psychology* New York, Plenum. Original work published 1934, written between 1929 and 1934).

Walls, P., Parahoo, K. & Fleming, P. (2010) 'The role and place of knowledge and literature in grounded theory' *Nurse Researcher*, 17(4), 8-17

Wang, M. T., & Degol, J. (2013) 'Motivational pathways to STEM career choices: Using expectancy value perspective to understand individual and gender differences in STEM fields', *Developmental Review*, 33(4), 304–340. .

Watt, L. (2016) Engaging hard to reach families: learning from five 'Outstanding' schools, *Education 3-13*, 44(1), 32-43.

Wellcome Trust (2014) *Primary Science: Is It Missing Out*? [Online].
Available: https://wellcome.ac.uk/sites/default/files/ primary-science-is-it-missing-out-wellcome-sep14.pdf.
[Accessed 13th September 2016]

Wellcome Trust CFE research (2017) *State of the Nation' Report of UK Primary Science Education* [Online].
Available: https://wellcome.org/reports/state-nation-report-uk-primary-science-education [Accessed 14th September 2019].

Wenger, E. (2010) 'Communities of practice and social learning systems: The career of a concept' In C. Blackmore (Ed.), *Social learning systems and communities of practice* London, England: Springer. 179-198.

Whetten, D.A. (1989) 'What constitutes a theoretical contribution?', *Academy of Management Review*, 14(4), 490–5.

Whitelegg, E. (2009) *Communicating science in informal settings. Block 3 of SEH804 Communicating Science in the Information Age*. Milton Keynes: The Open University.

Whiteley, A. (2004) 'Grounded Research: A modified grounded theory for business setting', *Qualitative Research Journal*, 4(2), 27-46.

Wigfield, A., & Eccles, J. S. (2000) 'Expectancy–value theory of achievement motivation. Contemporary Educational Psychology', 25(1), 68–81.

Wilcoxon, F. (1945). 'Individual comparisons by ranking methods' *Biometrics Bulletin 1,* 6, 80–83.

Williams, J. D. (2011) *How Science Works: Teaching and learning in the science classroom,* London: Continuum International Publishing Group.

Wilson, D. M and Chizeck, H. (2000) 'Aligning outreach with Cognitive Development: K-12 Initiatives in Electrical Engineering at the University of Washington', *Frontiers in Education Conference Proceedings*, 1, pp. T1E/12-T1E/17.

Wilson, F., Wade, N., & Evans, S. (2016) 'Impact of changes to practical assessment at GCSE and A-level: The start of a longitudinal study by OCR', *School Science Review, 98*(362), 119-128.

Wilson-Lopez , A., Sias, C., Smithee, A. and Hasbun, I. M. (2018) 'Forms of Science Capital Mobilized in Adolescents' Engineering Projects', *Journal of Research in Science Teaching*, 55(2), 246-270

Windsor, S. & Bailey, J. (2016) 'Impact of chemistry experiments outreach program on learning and attitudes for students in their penultimate year of schooling', *Teaching Science*. 62(1), 43-53.

Winter, C. (2017) 'Curriculum policy reform in an era of technical accountability: 'fixing' curriculum, teachers and students in English schools', *Journal of Curriculum Studies*, 49 (1), 55-74.

Wolfe, E. W., Converse, P. D. and Oswald, F. L. (2008) 'Item-Lever Nonresponse Rates in an Attitudinal Survey of Teachers Delivered via Mail and Web'*, Journal of Computer-Mediated Communication*, 14, 35-66.

Wong, V. (2019) 'Authenticity, transition and mathematical competence: an exploration of the values and ideology underpinning an increase in the amount of mathematics in the science curriculum in England'*, International Journal of Science Education*, 41(13), 1805-1826.

Wood, C. (2014) 'When might research impact be apparent' In Demicolo, P. (Ed.) *Achieving Impact in Research* London: SAGE Publications Ltd. 47-64

Wood, D. Bruner, J. S. and Ross, G. (1976) 'The Role of Tutoring in Problem Solving', *Journal of the American Academy of Child Psychiatry,* 17(2), 89.

Wooden, C. and Anderson, F. (2012) 'Engaging parents in reproductive health education: Lessons learned implementing a parent designed, peer-led educational model for parents of preteens', *American Journal of Sexualities Education,* 7(4): 461–473.

Woodward, C. & Woodward, N. (1998)' Girls and Science: Does a core curriculum in primary school give cause for optimism'?' *Gender and Education*, 10(4), 387-400.

Wright, S. (2006) 'The health of subjects: evidence from examinations entries, The Nuffied Review of 14–19 education and training'. Research Report 5 [Online]
Available: https://www.nuffieldfoundation.org/project/nuffield-review-of-14-19-education-and-training
Accessed 28th August 2018]

Wuensch, K. L. (2015) 'Non-parametric Effect Size Eliminators' *East Carolina University, Department of Psychology* [Online].

Available: http://core.ecu.edu/psyc/wuenschk/docs30/Nonparametric-EffectSize.pdf
[Accessed 22nd August 2019]

Yazilitas, D. S. Saharso, G.C. de Vries & J.S. Svensson (2017) 'The postmodern perfectionist, the pragmatic hedonist and the materialist maximalist: understanding high school students' profile choices towards or away from mathematics, science and technology (MST) fields in the Netherlands', *Gender and Education*, 29(7), 831-849.

Yeşiloğlu, S. N. and Köseoğlu, F. (2020) 'Epistemological problems underlying pre-service chemistry teachers' aims to use practical work in school science', *Chemistry Education Research and Practice,* 21(1), 154-167.

Zamawe, F. C. (2015) 'The Implications of Using NVivo Software in Qualitative Data Analysis: Evidence-Based Reflections' *Malawi Medical Journal*, 27(1), 13-15.

Zwartz, D. & Roop, H.A. (2016). Flakes, Blobs and Bubbles: An Ice Core Art Project. [Online.]
Available: http://icecoreart.weebly.com/
[Accessed 31st October 2017]

APPENDIX

APPENDIX A: A SNAPSHOT OF DIFFERENT SCIENCE OUTREACH PROGRAMMES ACROSS THE GLOBE

It is to be noted that this review does not encompass all outreach programmes that exist globally, but provides a narrative of the 'bigger picture' of science outreach in practice.

USA

Goodman (2002) describes the mission statement of the University Of South Dakota, School of Medicine (USDSM) and their involvement with schools within the area. As an educational institute they declare that it is important to actively prepare the next generation of Doctors and therefore run programmes for students in kindergarten through to the 12th grade (and undergraduate students). USDSM invited high school and undergraduate students from disadvantaged backgrounds to summer schools, which was made possible by the large grant they secured from the Howard Hughes Medical Institute (Goodman, 2002). This grant was provided to support educational activities for middle and high school students who were interested in the health professions as future careers to attend educational activities at the University of South Dakota. In addition to these activities, training was also offered to teachers to be able to use the travelling lab kits provided by the university which gave them access to resources not readily available at school. James, et al (2006) describe a similar scheme between East Carolina University department of mathematics and science, and K-12 schools in Greenville, North Carolina. Here, 50 % of schools are in rural districts, resulting in a higher number of students whose socio-economic status is deemed as low. This partnership feeds into the Eastern North Regional Science Center (ENRSC), which is also supported by the Center for Science, Mathematics, and Technology Education (CSMTE). Whilst faculty members from this partnership are able to visit these schools and deliver activities via the inquiry science approach, there is a great emphasis on providing continuing professional development (CPD) and support for teachers.

These very short descriptions of these university led partnerships evidence five out of the six features indicated by Jeffers et al. (2006). They also highlight how these outreach programmes are often a tool to engage children from disadvantaged backgrounds and aim to highlight potential professional and research careers for the students (Goodman, 2002). James et al. (2006) highlights how supporting teacher development in more rural areas will help with CPD and have a direct impact on pupils which they teach. However, Goodman (2002) does recall some difficulties with the implementation of the USDSM outreach programmes; stating time and cost can be a barrier. He also describes how there can be some animosity between scientists and teachers when it comes to ensuring the material is appropriate for the audience and often teachers do not feel comfortable having an "expert" in their classroom (Goodman, 2002, p. 173).

Canada

Scientists in Schools (SiS, 2018) is a non-profit science organisation which delivers science outreach to elementary students and their teachers. It consists of over 320 scientists and technical experts who offer half-day workshops where students are able to become 'scientists in their schools' (Shanahan, et al 2011, p. 131). The aims of this programme include: hands-on approaches to presenting ideas about science and technology; enhancing students' attitudes towards science and fostering an appreciation and awareness of science in a real-life context (SiS, 20 March 2018). Shanahan et al. (2011) describes a subset of results from a larger-scale two-year independent evaluation study between the SiS and two large school boards (education districts) in Ontario. The results from student responses (n=811) show that there was enhanced enjoyment and students and teachers were left feeling inspired; students from the underrepresented groups (based on language proficiency, gender and school achievement) did not provide any less positive answers (Shanahan et al., 2011). Thus, it is speculated that students may choose to remain studying science as enjoyment is deemed to be an important factor when making such subject choices (Braund, 2009). Shanahan et al. (2011) also highlight the reported increase in confidence of the application of scientific skills for these students; they suggest this may be due to the hands-on nature of this project.

This example outlines several features that are included in the framework provided by Jeffers et al. (2004), but the real learning from reviewing this programme comes from thinking about the age of the audiences which are involved with this outreach programme. Wilson and Chizeck (2000) suggest that too many outreach programmes are aimed at 14 year old plus students; they worry that they have already made decisions about science by then, which may reduce the lasting impact of these programmes. Flynn (2005) also supports this concern, as does Koehler, Park and Kaplan (1999) who suggest more outreach should be aimed at a younger audience.

Mainland Europe

Gumaelius et al. (2016) describe several outreach initiatives which universities have developed throughout Europe whilst also considering how these programmes support the proximity of the universities' everyday activities. As an example of some of these programmes which are quite separate to everyday operation, University College of Denmark and College Aalborg (AAU) within the city operate a programme called 'Universitarium' which was in response to a low interest in natural sciences and technology. The design of this programme stemmed from the model of 'Exploratorium' which was the world's first interactive science centre formed by Frank Oppenheimer in 1969 (Whitelegg, 2009). It was a place where visitors were encouraged to be active receivers of information and at the time marked a major shift in how these platforms for informal science learning could be designed. The 'Univeritarium' contains interactive exhibitions which families are able to visit in the holidays or schools are provided with private tours. One of the main aims of this programme is not only to inform participants about natural science, but also to place the natural sciences within a social context. From its initial development at the AAU it is now run by project managers, and many local businesses have become stakeholders in the science learning centre. Science students and student teachers at the university are the guides at this centre and along with any academic speakers who deliver additional programmes, they are all encouraged to develop their communication skills so that all lay audience members are able to access this information (Gumaelius et al., 2016). Whilst this example of science outreach does not involve school visits, its target audience is children and young people of school age.

'Vattenhallen' is a STEM programme operated by the Engineering Faculty at Lund University, Sweden and it is also deemed by Gumaelius et al. (2016) as a programme which is very separate to the everyday operation of the university itself. School children experience a 'two hours inspirational visit' which allows them to tour the university and experience hands-on group experiments; these follow a theme decided by the teacher (Gumaelius et al., 2016, pp 600). The programme is designed to increase recruitment in engineering and science programmes at the university and aims to balance some demographic differences such as gender or socio-economic background. Other programmes offered at this university include one week internships, summer courses and weekend or holiday open days for the public. The science shows such as; 'The Quantum Show', 'The Chemistry Show' and 'The Brain' attract hundreds of spectators, who are also welcome to visit the six-meter dome planetarium which housing in excess of 100 spectators per show (Gumaelius et al., 2016). Research surrounding the success of the programme indicated that teachers spent time in the classroom preparing for their visits to the facilities and did intend to follow up the learning afterwards, which indicated how these sessions may fit within the science curricula (Gumaelius et al, 2016).

Olafsson, et a (2009) describe how the University of Bergen, Norway constructed a 'Space Science Suitcase' which contained a set of simple science instruments able to monitor solar and geophysical activity in near-Earth space. What is appealing about this science outreach initiative is that it has been developed with the school science curricula at its core and aims to promote scientific literacy. In Norway, students are expected to describe how the Northern lights arise and recognise how this area of research is important for the country, this then links to concepts about pollution, radioactivity and the electromagnetic spectrum. Its aim is to offer students the opportunity to study the phenomena in a 'hands on' manner with equipment not readily available at school. They also recognise the need to excite future scientists and therefore, this outreach programme aims to inspire interest to study physical sciences at University (Olafsson, et al., 2009). The suitcase itself is lent to physics classes in the last year of upper secondary school and as part of the programme it encourages students to share their results on an online platform and at the end produce a presentation and evaluation summarising their findings. Strømsholm (2011) explains that this suitcase was used during the international Year of Astronomy in 2009 to allow pupils to take part in the exciting and topical research. It was also pivotal in introducing scientific methods to younger students; which is identified as an important aspect of the curriculum.

Stockholm University offer a summer school for high school science students within the Stockholm region. This outreach programme invites active researchers and PhD students to design hands-on activities for the students to experience. This means that all the activities link to current science and because of the university setting, students are able to access university equipment that they may not have access to at school. To be involved with this outreach programme, it is the students who sign up based on their own interests, and then they are selected using a lottery system (which does not link to science grades). Local teachers are aware of this programme and therefore the university invites them to attend annual meetings in which they can offer feedback about the programmes which their students may have experienced. It is a popular programme that is designed to increase interest and engagement in science; each year about 800-900 students apply for the 126 available places (Gumaelius et al., 2016).

All of the above examples encompass most of Jeffers et al (2004) framework. What is probably more evident from just these small snap-shots of some science outreach initiatives operating in Europe is that the literature is quite specific about how these activities have a purpose to engage future scientists. All of these examples outline how Universities in several European countries are key stakeholders in the design of these programmes, this reiterates DeCoito's (2016) views that these institutions are needed to foster learning in STEM.

UK

Muller et al. (2013) described 'The Blue Marble' project that is funded by the UK Space Agency and has been developed between the University of Leicester and University of Nottingham with primary schools. It is designed as a hands-on workshop that includes drama and roleplay where 5-11 year olds are able to spend a day learning about different space technologies and the role of a research scientist. Its content means that the learners are able to engage with a range of disciplines such as: mathematics; technology; science and engineering as well as the 'how science works' which was previously part of the science National Curriculum (University of York, n.d.). The aim of the programme is to allow those who attend to see how anyone can be a scientist and how it draws on a range of subject interests (Muller et al., 2013). The success of this programme was evaluated by Primary Partnerships (PP) which is a social enterprise company who foster contacts between primary schools (catering for students aged 4-11 year old) and different organisations. Their evaluation consisted of a measure of effectiveness and impact by a series of before and after questionnaires with the children. Amongst the range of data it was found that there was a 22% increase in pupils thinking that they would want to become a scientist after experiencing the workshop. Words associated with the views of science also changed as positive responses such as 'fun', 'brilliant' and 'amazing' went up and words such as 'geeky', 'nerdy' and 'weird' went down. Muller et al. (2013, p.182) attribute this change in the words expressed due to the children's encounter with a 'real life scientist'.

Illingworth and Roop (2015) explore two case studies of outreach work within the field of Geography, Earth and Environmental Sciences (GEES). The first example was designed by researchers from the Centre for Atmospheric Sciences (CAS) at the University of Manchester for GCSE (15-16 year old) and A-level students (post-16 year old). Students complete a circuit of events such as building a weather station, spectroscopy activities and a 'Do You think' workshop. Teachers expressed positive feedback about the programme in terms of both learning outcomes and about the facilitators who delivered the workshops. The outreach programme was sustained by the constant training of PhD students and postdocs which meant sufficiently experienced adults were always available to deliver the programme. It was found that those who facilitated the outreach work also had very positive experiences and they developed some key transferable skills such as increasing their confidence in speaking to new audiences and improved their verbal communication; thus, the facilitators were benefitting from these expeirnces too (Illingworth and Roop, 2015).

The other example, again discussed by Illingworth and Roop (2015) centred on the International Polar Week (IPW) which is a bi-annual event held at the time of the equinoxes each year. Thirty-five researchers and teachers designed an activity entitled ‘Flakes, Blobs and Bubbles: An Ice Core Art Project’ which focused on combining the science of ice cores as a record of climate change and art. Supplementary information and videos were provided about how ice cores could document changes in the environment and the art activity asked learners to draw different phases of ice formation (Zwartz & Roop, 2016). More than 1,000 submissions from learners aged 10 to 18 years old were submitted to a specified email address to be coded into a ‘global ice core image’ (Illingworth & Roop, 2015, p. 7). However, the main success was said to be the collaboration of researcher, scientists and teachers as this highlighted the willingness and enthusiasm of teachers and scientists to assist one another in creating a workable and successful resource.

Bristol ChemLabs is a chemistry outreach programme based within the chemistry department at Bristol University and has been operating for over 10 years (Glover, Harrison & Shallcross, 2016). Thus far, Glover et al. (2016) estimate that over 25,000-30,000 students engage with Bristol ChemLabS’ outreach provision on a yearly basis. Bristol ChemLabS Outreach work developed a programme which drew on a variety of activities in order to meet the needs of different schools. The Open Laboratory Programme was able to accommodate school science students (11-18 year olds) on a Wednesday afternoon and out of term times to experience practicals within this setting. There was a science teacher fellow (STF) who was a former secondary school science teacher working with the university who was crucial to the design and implementation of these practical activities as they were able to draw on their knowledge and understanding of the curriculum. They were also able to prepare relevant health and safety forms which made the school teacher’s job less problematic when gaining approval to facilitate out of school learning. Summer schools were run by the University of Bristol and attracted several overseas students. It was an opportunity for young people not only to experience chemistry in a setting similar to the design of The Open Laboratory Programme but also explore their own attitudes about progressing onto Higher Education (HE). These Bristol ChemLabs summer schools have also been disseminated in other countries such as Singapore and South Africa, in which the facilities of the host country have been used to provide similar programmes to those further afield. There has also been a Lecture Programme established, whereby school students can visit the university to listen to lectures, which include practical demonstrations. Some of these lectures have been adapted and have been delivered across five continents.

The funding initially provided by the Higher Education Funding Council for England (HEFCE) was also utilised to engage primary aged children and the money was used to buy equipment and labcoats to be able to deliver workshops in local primary schools. Competitions such as 'Chem@rt' were launched to promote science to younger school aged pupils (4-11 years old). They had to explain scientific concepts visible in the images provided by Bristol ChemLabS, by presenting their work. It also allowed opportunities for pupils to embed important literacy skills.

These range of outreach activities in the UK exemplify the common partnerships between universities, science centres and schools to provide a platform for science outreach events. This range of science outreach activities consider all features of Jeffers et al (2004) framework and in particular how outreach can be used to support younger learners. Muller et al. (2013) indicate the impact such a programme could have on younger learners, even just after one day. This then presents ideas about the sustainability of the impact on science outreach work. This is something that is usually difficult to monitor as it is often student feedback or enrolment numbers that are generated and analysed after an event, and this can be difficult to monitor over time (Alexander, Waldron & Abell, 2011; Shanahan et al., 2011; Shaw, Harrison & Shallcross, 2010). However, Bristol ChemLabS has self-evidencing success of their chemistry outreach programme by the fact that this was initially only funded for five years, which has now extended and expanded beyond the time frame (Shallcross et al., 2013). Schools have had many positive experiences of the chemistry outreach programme and are now willing to pay for the services of Bristol ChemLabS (Shaw et al., 2010).

Asia

A science outreach programme in Seoul, Korea utilises the space science museum (Lee, Jo & Choi, 2011). Its exhibits encourage hands-on activities such as making rockets. The programme introduces the idea of 'edutainment' which combines the principles of education and entertainment to make learning 'fun' (Lee et al., 2011, p. 732). Another outreach programme which was developed through this scheme was the 'Young Astronaut Korea' (YAK) which was established in 1989, and coincided with the development of Korea's space programme. The space science camp and aerospace science competition attracts participants from elementary to high school students and there is even a 'Teachers Space Science Camp'. All these have the principle aim of promoting space education as a means to invest in the future growth and progress in space science and technology in Korea (Lee et al., 2011).

In India, there was also a recognition that science in classrooms had become very exam focussed, rather than looking at the more practical and engaging aspects (Singh et al, (2015). There were also shared concerns that even if a school may have wanted to include more practical aspects in their science lessons then there may be a lack of facilities or expertise. Therefore, a team consisting of undergraduate students and researchers ran an outreach programme entitled 'Science is fun' that delivered science workshops to underprivileged learners across educational levels (4-16 year olds). Singh et al. (2015) describe how the workshops explored scientific concepts and then followed these up with hands-on activities. The students responded well to these activities but those who delivered the workshops also attempted to involve the teacher so that activities could be repeated or adapted in future lessons.

These examples promote engagement in science to inspire future scientists. Even in these brief descriptions of the science outreach activities, they highlight three of approaches highlighted by Jeffers et al.'s (2004) framework. These are, active learning through hands on engagement, curriculum supplements and teacher involvement.

Australia

In Canberra, Australia the Australian National University have designed a programme known as 'Science Extension Day' (Fletcher, 2016). This aims to build a community partnership between all school educational levels and a university focusing on building an educational pathway for students to a science career. The structure of the programme sees 14-15 year old student mentors working to engage 5-11 year old school students, with an open-ended task linking to the scientific disciplines. They then work as a team in a university setting to complete the task. This programme was developed in September 2015 and although it is still in its infancy, Fletcher (2016) recalls the positive responses of the students who took part in the programme and described how both younger and older students enjoyed working in a university setting.

Another science outreach programme attempted to monitor the impact on student's learning by conducting pre and post quizzes (Windsor & Bailey, 2016). Three schools within the North Coast Region of Education, Queensland approached a chemistry department at the University of the Sunshine Coast (USC) to ask to provide students with a chemistry outreach programme in which they were able to conduct experiments (Windsor & Bailey, 2016). It was the teachers themselves from the school that outlined the desired topic of the experiments and the quizzes aimed to test practical and theoretical knowledge of the 16-17 year old students. However, whether a school attended one session or several sessions there was no difference in impact on the 46 students' attitudes towards science, which was an initial aim of the developed outreach programme. This is explained by Flynn's (2005) argument that by high school, students have already made up their minds about science. Windsor and Bailey (2016) therefore question the age at which these programmes are implemented and provide a critique for the impact of science outreach programmes.

The Australian science outreach activities highlight that there are a range of ages of participants who are catered for. It also features several aspects of Jeffers et al. (2004) framework, namely, engaged role models and active learning through hands on experiences However, both provide examples and rationales for focusing outreach on younger learners.

<u>Africa</u>

The importance of recruiting future scientists and engineers is a global focus, but in developing countries such as Africa access to other initiatives such as outreach activities, may be even more limited. Therefore, a national strategy recommended the use of computer-based outreach programmes in two disadvantaged schools to further engage learners. Computer-assisted learning (CAL) was to be integrated into the classroom as an opportunity to provide applications that go beyond traditional modes of instruction and can provide new opportunities for the teaching and learning of maths and science. It was also intended that this CAL could promote collaborative learning to illustrate elementary science concepts. (Oshima et al., 2004). It was found that teachers used these ‘outreach’ resources in different ways but learners interviewed commented on how this programme was a positive step to improving learning. However, the students highlighted that they still felt that the role of their teacher was important in developing their confidence and performance in examinations (Hartley, Treagust & Ogunniyic, 2008). Whilst this example of an outreach programme is quite dated, it highlights how technology can be used to deliver outreach activities when cost and human resources are limited. Hartley and Treagust (2014) reviewed the impact of CAL that was implemented to assist in mathematics at a similar time. General feedback obtained from a Computer-Assisted Learning Environment Questionnaire (CALEQ), specifically designed for the South African context indicated that CAL positively assisted with their application of the subject and they enjoyed more problem-solving activities. Findings from this study recommended that more computers should be made available to enable students to access these programmes individually (Hartley & Treagust, 2014). Whilst these findings are linked to the mathematics programmes, this CAL outreach opportunity provided disadvantaged learners with an opportunity to access information that would go beyond a normal lesson. However, an important finding was that the role of the teacher was central to the engagement with the activity (Hartley et al., 2008).

Another example comes from the years 2007-2009, which stemmed from the International Year of Planet Earth (IYPE); this placed an international focus to narrow the gap in terms of supply and demand for geoscientists (De Mulder et al., 2014). The strategy to engage future geoscientists followed a successful model some years before in 1957-1958 whereby outreach activities linked to the Geophysical year helped to recruit more geoscientists at HE level in the subsequent years. Although this example of an outreach activity provides research much further afield than Africa, 14 of the 80 nations involved originated in this county. A particular feature of this outreach activity was that upon the closure of IYPE, the Earth Science Matters Foundation (ESMF) was established to continue this type of outreach work across the continent. Aims of both of these outreach initiatives were to excite (younger) people in Earth Science and inform society about how this field of science adds value to society; both in terms of the economy and the environment. Some of the outreach activities that ran in schools from the IYPE and ESMF included: national school debating competition in Nambia and Mauritius; environmental kits provided to schools in Angola and geo kits in Togo and an art and geoscience programme for schools in Morocco. In addition, the University of Botswana organised a geology club involving over 500 high school students (De Mulder et al., 2014). In their review of

Geoscience outreach in Africa between the years of 2007-2013, De Mulder et al. (2014, pp. 744) suggested that “geoscience outreach is an effective way to inspire the general public; in particular youngsters”. In the following years there was a spike in numbers of students enrolling to different Earth Science courses in different universities across the country. However, the authors also highlight many challenges when it came to delivering these activities, which reflect similar barriers that transcend across many countries.

Looking at these science outreach initiatives in Africa, they highlight how some places more than others, have limited resources to be able to deliver such activities (more so than even in the Western world); Hartley et al. (2008) highlight this unequal distribution of human resources in South Africa, particularly in science, engineering and technology (SET). This lack of human resource to inspire individuals in turn may lead to a shortage of learners studying this field at tertiary level and therefore the situation becomes even worse. Hartley et al. (2008) highlight that although concern centres around studying at tertiary level, it was a learner’s experience of learning science and maths at secondary level that affected those who continued to study the field of SET. It is therefore promising to explore the other example linked to geoscience that has persisted beyond its conception in 2007. Both these examples include features of the approaches identified by Jeffers et al. (2004) such as supporting the curriculum, involving teachers, providing hands on activities and a focus on younger learners.

Middle East

Literature surrounding science outreach programmes in the Middle East, is fairly limited. Tafreshi (2011) discusses how astronomy in Iran regained popularity in more recent years, and attributes this to the monthly Iranian astronomy publication named *Nojum*. What started as a magazine has evolved into a hub for organising astronomy activities in Iran; for both amateurs and professionals alike. There are evening classes held in schools and universities, community programmes and conferences. From these gatherings the Astronomical Society of Iran’s outreach and amateur committee (ASIAC) was formed in 2002 to organise national level programmes and competitions. Tarfreshi (2011) describes how despite many enthusiastic participants to these events, political and financial problems in the country as a whole mean that funding for these outreach opportunities is limited.

Erol, Buyuk and Tanik Onal (2016) also comment on the lack of equipment and human resources to support science courses in rural parts of Turkey. In different regions of Turkey the distribution of the educational resources are skewed and many learners will therefore have very different experiences of education. One of these solutions was to construct a mobile science laboratory (MSL) to deliver outreach activities in rural parts of Turkey. These are funded by the Leonardo Da Vinci Centre for European and Youth Programmes (EACEA, n.d.); it allowed up to 12 students at a time to undertake scientific experiments. The MSL contains a main laboratory, a preparation area and a staff area. It is fully fitted with heating, lighting, ventilation, water and the internet. The programme encouraged hands-on activities and demonstrations linked to many disciplines in science but they were not on the Turkish Science curricula; Erol et al. (2016) highlight that the activities were used to inspire interest in science. Feedback about this programme was sought from 324 students who engaged with the MSL. The average age of the participants was 13.08 years old and they attended schools in 10 different rural towns in Yozgat, they answered point questions using a Likert scale and had to respond to two open questions. It was outlined that, in general, students felt positive about their experience and they felt the MSL was a useful tool in science education. It was also felt that this outreach programme was a useful tool to motivate learners in science as 94.5% of participants stated that it had increased their interest in science. 84.9% of students also commented on the enthusiasm of the instructors in this outreach activity.

When considering these two examples they highlight how lack of resources can limit science education in general; science outreach programmes can therefore be an example of how to reach more remote areas that maybe constrained. Both examples highlight the importance of role models and those promoting these outreach activities; this is included in Jeffers et al. (2004) approaches to outreach activities.

APPENDIX B: AN EVALUATION OF A SUCCESSFUL MODEL OF SCIENCE OUTREACH IN THE UK

As research into the success and impact of science outreach programmes is somewhat limited it is useful to present a 'success' story. The next section presents a chemistry outreach programme that operates in the South West of England; understanding the content and impact an individual case study can depict these types of programmes in general and provide useful considerations for the model developed.

What is Bristol ChemLabs?

There have been very few examples whereby impact has been measured over a period of time. However, Bristol ChemLabs is a chemistry outreach programme that provides a unique opportunity to evaluate the longitudinal impact of the outreach programme due to the continuity and constant updates, since its inception. Bristol ChemLabS is based within the Chemistry department at Bristol University and has been operating for over 10 years (Glover et al, 2016). Shallcross et al (2013 p.39) explain how this initiative was derived "in 2005 as the Higher Education Funding Council for England (HEFCE) invested about £300 million to establish 74 Centres for Excellence in Teaching and Learning (CETL)." From 2005-2010 funding was provided for the CETL and the aim was that after this date each CETL would be sustainable and operate unaided. Bristol ChemLabS was a CETL dedicated to chemistry and is not only still operating but also expanding, which indicates the success of this programme.

Glover et al (2016) estimate that over 25,000-30,000 students engage with Bristol ChemLabS' outreach provision on a yearly basis. Shallcross et al (2013) describe some of these outreach activities and how the funding allowed focus to be placed on the teaching and learning of practical chemistry at university. Another branch of the funding for Bristol ChemLabS was used to develop and enhance outreach work which already took part within the university department. £150,000 was made available to spend on outreach within the university, which was in addition to the appointment of a Science Teacher Fellow (STF) over this 5 year time period. The STF was a role that has not been used within the design of outreach work; they had initially been employed for one year as a secondment from being a secondary school teacher, however, the success of their role meant they were utilised for much longer and other universities have adopted this approach. Even the Royal Society of Chemistry (RSC) adopted a similar approach in their programs entitled 'Chemistry: The next Generation' and 'Chemistry for Our Future' (Tunney, 2009 in Shallcross et al, 2013 p. 41).

Programmes on offer at Bristol ChemLabS

Bristol ChemLabS Outreach work developed a programme which showed variety to meet the needs of different schools. The Open Laboratory Programme was able to accommodate school science students (11-18) on a Wednesday afternoon and out of term times to experience practicals within this setting. The STF was crucial to the design and implementation of these practical activities as they were able to draw on knowledge of the curriculum and also prepare relevant health and safety forms which made the school teacher's job easier and slightly less problematic when gaining approval to take a group of pupils off the school premises. Summer schools were run by the University of Bristol and attracted several overseas students. It was an opportunity for young people not only to experience chemistry in a setting similar to the design of The Open Laboratory Programme, but also to explore their own attitudes about progressing onto Higher Education (HE). These summer schools have now established themselves beyond the five years funding and have been disseminated in other countries such as Singapore and South Africa, in which the facilities of the host country have been used to provide similar programmes to those further afield (Shallcross et al, 2013).

In addition to the Open Laboratory Programme and the Summer Schools, Bristol ChemLabS developed a Dynamic Laboratory Manual (DLM) which was designed to assist A-level students with practical chemistry. There was also a Lecture Programme established whereby school students visited the university to listen to some lectures which included some practical demonstrations. Some of these lectures have been adapted and are now delivered in schools, much further afield than the South-West of England. This links into the overseas programmes which have taken place on five continents that aim to deliver the success of this outreach work to a wider audience. The funding from the HEFCE was also used to engage primary aged children and the money was used to buy equipment and labcoats to be able to deliver workshops in local primary schools. Competitions were also used such as 'Chem@rt' which aimed to promote primary school aged pupils to explain scientific concepts visible in the images provided by Bristol ChemLabS and in presenting their work it allowed opportunities for pupils to also embed important literacy skills.

Teachers were also considered as part of these chemistry outreach programmes as they were encouraged to engage with the CHeMneT network which allows Bristol ChemLabS to interact with science teachers and also other interested parties mainly within the South-West of England and South Wales, but is open to the rest of the UK and beyond (Glover et al, 2016). Bristol ChemLabS also considered Continued Professional Development (CPD) for teachers to attend to assist with their own practice or to enable them to deliver masterclasses for those teachers for whom chemistry is not their first speciality. They have also driven and challenged scientists and students from the world of academia to write work that would be suitable for a school-level audience. This has been beneficial not only for the school to hear about new areas of research, but also useful for the scientists in being able to develop their communication skills (Shallcross et al, 2013).

Teachers perceptions of the impact and success of Bristol ChemLabS

This outreach programme was also selected as a 'case' within this literature review as it also monitored teacher's involvement and beliefs about being involved in the science activities. This point of view is important as it aligns with the research aims of this study and can assist with further considering the research question regarding teachers' perceptions of theseprogrammes.

Teacher's view of the impact of this programme

As some time has passed since the initial start-up of this CETL there has been a lot of time dedicated to monitor the impact of this Outreach Programme on schools, the teachers and even the general public (Shaw et al, 2010; Harrison et al, 2011; Shallcross et al, 2013; Sewry et al, 2014; Glover et al, 2016). Shallcross et al (2013) identify that the awards and subsequent funding that Bristol ChemLabS have gained since the HEFCE funding stream ended in 2010. It is also observed that the outreach programme had a positive impact evidence by those who attended and then decided to apply to study chemistry at Bristol.

When teachers were asked about their view of the impact of Bristol ChemLabS outreach work within their school, an individual stated that (Shaw et al, 2010 pg. 20):

"it is too difficult to attribute anything to one thing in particular"

This highlights the main essence of the issues when it comes to monitoring the impact of outreach work. However, research by Shaw et al (2010) and Glover et al (2016) have interviewed teachers who have been involved with the programme for a considerable period of time. Shaw et al (2010) used CHeMneT to recruit teachers to be involved with this study, but those involved did so on a voluntary basis. Of the 169 contacted, 12 full interviews were conducted. In the later research of Glover et al (2016) whilst, they did use CHeMneT to contact schools, they had initially identified those institutes which has been involved with Bristol ChemLabS since its conception in 2005. Of the 12 teachers contacted, 9 were interviewed fully. In both pieces of research it was the individual teacher's views that were important, if they had moved schools but had still remained involved with Bristol ChemLabS outreach programmes then it did not matter as it was their perceptions of the impact that was needed, not the individual pupils. It is described how most of these outreach activities have focused on student feedback, but teachers may be able to provide much further insight as "teachers pay an integral part in the success of science outreach events" (Shaw et al, 2010 pg. 15). This indicates the important role of the teacher as they are the stakeholders which essentially choose whether or not to engage their students with these types of programmes, as without the support of the teacher, the students may not have the opportunity to participate. Teacher's perceptions are also a great tool to be able to monitor short-term and long-term impact on their pupils as they know their students much better than any person(s) interacting with them for a short period of time. Teachers are able to gauge their students before and after any outreach activities so are the best people to 'judge' any changes or consequences of taking part as they can discuss a number of factors such as attitude, understanding and attainment of an individual (Shaw et al, 2010).

Shaw et al (2010) found that out of 12 of the teachers interviews 7 of the believed that there were long-term effects, which included a rise in students choosing to continue with their studies in science at A-level and beyond. For the remaining teacher, 3 indicated that they thought it was too difficult to observe any effect, whilst the remaining 2 did not feel that there was long-term impact. However, all teachers that were interviewed as part of this study suggested that their students' involvement has enhanced interest in chemistry and indicated their wish to continue participating within the Outreach Programme and Bristol ChemLabS. When teacher were asked in this study about why they wanted their students to take part in the outreach events provided by Bristol ChemLabS they suggested links to supporting learning in science. Shaw et al (2010) notes that this is often the case as teachers have to justify why they are taking their students off the school premises during school hours. However, what was found in the interviews was that when discuss the impact of these activities most of the benefits linked to motivation and the opportunity for their students to be exposed to university 'life'.

Why teachers chose to keep engaging with the outreach programmes offered by Bristol ChemLabS

In a similar study conducted by Glover et al (2016) teachers were asked about why they engaged in a long-term partnership with a university (Bristol) and their responses linked to their experiences with the Bristol ChemLabS outreach programme. Those 9 teachers involved mentioned the long-term effects on their students which linked to increased motivation, enjoyment, inspiration when visiting a chemistry department at a university. They indicated how this experience helped to raise aspirations of their students whilst their partnership involved curriculum support, extension of their student's learning and promoting stretch and challenge. These findings reflect similar views expressed in Shaw et al's (2010) study. When the teachers in this more recent study were asked to comment on the success of the outreach programmes, they often mentioned the STF by name or commented on the work they did. Teacher's felt that that the STF offered flexibility and tailor-made experiences though their communication with the individual teachers from the school. Glover et al (2016) discuss how the STF stands out as the main person with whom teachers have a relationship as part of this partnership, finding that the teacher attributes this good working relationship to the fact that the STF is an experienced secondary school teacher who understands pupil's needs. Teacher's also commented that the role of post-graduate science students helped to inspire and excite their pupils and described how these students are "breaking the stereotypes…meeting real scientists…huge value for my girls seeing female PhD students" (Glover et al, 2016 pg. 87). It was discovered however, that very few teachers planned pre or post visit activities and although some teachers comment on opportunities to carry out required A-level practicals and experience Spectroscopy in a Suitcase, it was highlighted that due to class sizes only a few of their students could experience these valuable activities. Therefore, Teacher 6 questioned the sustainability of these outreach programmes to aide the curriculum as it cannot support science learning for the whole year group, but how it can be an "amazing opportunity for G & T (Gifted and Talented) kids to stretch and challenge" (Glover et al, 2016 pg. 87).

Crossing international borders

There have been benefits for both the teachers and students involved in the outreach programme developed by Bristol ChemLabS delivered in South Africa. The impact for the students involved and delivering such programmes to the community link to the soft skills that the young chemists develop, and are sought by local employers. It may also help with local student recruitment and it has also been seen to pave the way to new research areas, such as ideas about the atmosphere after the delivery of 'A Pollutants Tale' which linked to climate change. The programme also engaged teachers as laboratory sessions allowed teachers who were either not confident or competent to visit Rhodes University in South Africa to deliver or arrange these practical learning sessions for their students (Sewy et al, 2014). These workshops for the teachers were also important, especially after the introduction of the new physical sciences curriculum, to help with the implementation. The teachers decided the weekly topics and they were able to request help in terms of pedagogy and knowledge.

Harrison et al, (2011) consider how delivering these sessions away from the 'home' country allows both stakeholders to learn from each culture which can inform future programmes. There are still pragmatic issues linked to training and recruitment of local demonstrators, along with transport issues due to the rural nature of some of these areas. However, although it can be initially difficult to set up, once established there are many positives for both the recipients and providers.

How findings from Bristol ChemLabS may inform this research project

Bristol ChemLabS has self-evidencing success by the fact that this five-year funded scheme has now extended and expanded beyond the time frame. Schools have had many positive experiences of the chemistry outreach programme and are willing to pay for the services of Bristol ChemLabS. In terms of impact, the research that surrounds Bristol ChemLabS is attempting to monitor the impact it has on students it encounters and due to its longevity it is able to work with teachers and schools who have been involved in the programme for over a decade. This therefore, provides unique impact into the values and feasibility of their own chemistry outreach programme whilst also sharing good practice and outreach models to be carried out in other institutes.

The insight into perceptions of teachers of Bristol ChemLabS assisted with questioning and analysis of data when looking at themes to focus on. It is also the only science based outreach programme that has looked into ideas about 'long-term impact' and 'teachers' perceptions'. However, Bristol ChemLabS operates on a local level which is specific to their programme and this project aims to take on board perceptions of teachers who experience a different quality and quantity of outreach activities. It is interesting to draw on similarities and differences of views and explore whether positive experiences link to the successes highlighted in review of the CETL at Bristol University.

Appendix C: Data table of schools in the NW of England

Data obtained from a collective of school authority websites 7th Oct 2016.

Number allocated	School Local Authority	Total primary schools	Total Secondary schools	Total FE Institutes
1	Blackburn with Darwen	56	12	2
2	Blackpool	31	7	2
3	Bolton	98	21	3
4	Bury	63	13	2
5	Cumbria	30	37	5
6	Cheshire East	132	21	3
7	Cheshire West and Chester	142	19	3
8	Halton	51	8	1
9	Knowsley	57	6	1
10	Lancashire	489	85	13
11	Liverpool	135	31	1
12	Manchester	138	26	5
13	Oldham	85	14	2
14	Rochdale	66	12	2
15	Salford	76	15	1
16	Sefton	77	19	4
17	St Helens	30	9	2
18	Southport	85	14	3
19	Tameside	75	15	3
20	Trafford	71	18	1
21	Warrington	69	13	2
22	Wigan	104	19	4

23	Wirral	38	21	2
	TOTAL	2198	455	67

APPENDIX D: ETHICS APPROVAL AND PARTICIPANT/GATEKEEPER INFORMATION SHEETS

Ethics approval notification Stage 1 and 2 (Questionnaire and interview)

Approved - Brennan

You forwarded this message on 15/05/2017 11:14.

Ethics stage 1 and 2 V2 with ammendments.pdf
692 KB

Dear Victoria

With reference to your application for Ethical Approval:

16/TPL/013 - Victoria Brennan, PGR - Teachers' perception of chemistry outreach work as a sustainable intervention tool which can have a lasting impact; particularly with pupils from a lower socio-economic background. (Andrea Mallaburn/Linda Seton)

The University Research Ethics Committee (UREC) has considered the above application by proportionate review. I am pleased to inform you that ethical approval has been granted and the study can now commence.

Approval is given on the understanding that:

- any adverse reactions/events which take place during the course of the project are reported to the Committee immediately;
- any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately;
- the LJMU logo is used for all documentation relating to participant recruitment and participation e.g. poster, information sheets, consent forms, questionnaires. The LJMU logo can be accessed at http://www.ljmu.ac.uk/corporatecommunications/60486.htm

Where any substantive amendments are proposed to the protocol or study procedures further ethical approval must be sought.

Applicants should note that where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

For details on how to report adverse events or request ethical approval of major amendments please refer to the information provided at http://www.ljmu.ac.uk/RGSO/93205.htm

Please note that ethical approval is given for a period of five years from the date granted and therefore the expiry date for this project will be December 2021. An application for extension of approval must be submitted if the project continues after this date.

LIVERPOOL JOHN MOORES UNIVERSITY

Mandy Williams, Research Support Officer
(Research Ethics and Governance)
Research and Innovation Services
Kingsway House, Hatton Garden, Liverpool L3 2AJ
t: 01519046467 e: a.f.williams@ljmu.ac.uk

APPENDIX E: EXAMPLE OF COMPLETED QUESTIONNAIRE ON PAPER AND ONLINE

Paper

LIVERPOOL JOHN MOORES UNIVERSITY

30 P

LIVERPOOL JOHN MOORES UNIVERSITY

Title of Project: *Teachers' perception of chemistry outreach work as a sustainable intervention tool which can have a lasting impact; particularly with pupils from a lower socio economic background.*

Name of Researcher and School/Faculty

My name is Victoria Brennan and I am a PhD student within the School of Education, Faculty of Education, Health and Community at Liverpool John Moores University. You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Please ask if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

1. What is the purpose of the study?

This study wishes to explore teachers' views about science/chemistry outreach programmes delivered both internally and externally, and whether this type of work can have a lasting impact, particularly when it comes to students' choices post-16. Even though the initial focus is to look at chemistry outreach work, it is acknowledged that at primary level, or where schools do not teach science separately then these programmes may not be delivered as 'pure chemistry'. All experiences and views of science outreach work are valued as part of this study, as it is these views that will assist in providing a 'better model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

2. Am I eligible to take part?

Teachers from randomly selected schools in the north-west of England will be asked to participate in this study. At primary level all teachers are invited to participate, whereas at secondary and tertiary level these will only be distributed to general science/chemistry teachers.

3. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive. However, due to anonymity of the data collection it is not possible to withdraw once you have submitted your questionnaire either by paper or online. Therefore, it advised that you consider your participation within this study.

4. What will happen to me if I take part?

The questionnaire should take about 10 minutes to complete. Most of the questions are closed and ask you to tick a box, there are only a few questions which you are asked to complete freely.

The final question will ask you whether you are happy to be involved in the next stage of the study which involves a face-to-face interview. Even if you are happy to provide further contact details this does not mean you are committing to being involved within the next stage of this study. It may also be that due to selection criteria of the next stage, you may not in fact be eligible to continue in this study.

5. Are there any risks / benefits involved?

Participation in the questionnaire stage will provide valuable insight into teachers' perceptions of science/chemistry outreach programmes.

There are no perceived risks involved when completing this questionnaire.

LIVERPOOL JOHN MOORES UNIVERSITY School of Education

6. Will my taking part in the study be kept confidential?

All of the completed questionnaires will be stored in a secured, lockable location whereby no personal data will be shared. Each completed script will be coded and no personal details, including name of the school, will appear in the research paper. If you are concerned about any aspects of confidentiality before you start the questionnaire, or during the process please do not hesitate to ask any questions. Additionally, if you have any concerns about your involvement after the event you are free to contact either myself, the researcher, my Director of Studies Dr Andrea Mallaburn or the ethics committee.

This study has received ethical approval from LJMU's Research Ethics Committee *16/TPL/013* approved on the 21st December 2016

Contact Details of Researcher:

Victoria Brennan

Room H003 Holmefield House

I.M.Marsh

Barkhill Road

Liverpool

L17 6BD

Email: V.K.Brennan@2016.ljmu.ac.uk

Contact Details of Academic Supervisor:

Dr Andrea Mallaburn

I.M.Marsh

Barkhill Road

Liverpool

L17 6BD

Telephone: 0151 231 5380/5259

Email: A.Mallaburn@ljmu.ac.uk

If you any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

LIVERPOOL JOHN MOORES UNIVERSITY School of Education

BEFORE YOU START

If you would rather complete this questionnaire online please visit https://ljmu.onlinesurveys.ac.uk/teachers-perceptions-of-chemistryscience-outreach-work-2 **or you can scan the following QR code**

CONSENT

☑ *I have read the information sheet provided and I am happy to participate. I understand that by completing and returning this questionnaire I am consenting to be part of the research study and for my data to be used as described.*

INTRODUCTION

When considering the rationale behind science outreach work, the Royal Society of Chemistry (RSC) describe their aims of outreach programmes as follows:

"We support a broad range of activities to inspire and enthuse the next generation with chemistry. Our programmes offer school students the opportunity to engage with practising chemists and learn about the application of the chemical sciences in the real world."

(RSC, *Campaigning and Outreach for educators*, 2016)
http://www.rsc.org/campaigning-outreach/outreach/educators/

The following questions are designed to explore your own views of what these types of programmes involve and how useful you perceive them to be. In each question you are asked about science/chemistry outreach work as 'chemistry' as a discipline may not be taught explicitly.

LIVERPOOL JOHN MOORES UNIVERSITY School of Education

QUESTIONS

1. Please indicate the educational level(s) of science you teach *(please select all that apply)*

KS1	✓
KS2	✓
KS3	
KS4	
KS5	

2. Please describe your understanding of 'science outreach work'
You may provide any examples of this type of work and where it may takes place, please continue on a separate sheet if you wish.

I don't fully understand 'science outreach' work.
I would imagine it is independent agencies coming in to work with small groups of children / classes.

3. Please indicate what you consider to be part of science/chemistry outreach programmes:
Please select all that apply

Science/STEM Clubs	✓	Science shows	✓
Visits to Universities		Links with local industry	✓
Science Fairs		Extension work in science	
Extra homework		Guest speakers	✓
Placements		Science careers day	
Science competitions		Other	

4. Regardless of the current level which you teach, please complete the following by placing a tick in **one space** only as follows:

1=Not at all, 2=very little, 3=a little, 4= quite a lot, 5=a great deal

a. How important do you consider science outreach work to be at primary school level?

1	
2	
3	✓
4	
5	

b. How important do you consider science/chemistry outreach work to be at secondary school level?

1	
2	
3	
4	
5	✓

c. How important do you consider chemistry outreach work to be at sixth form/college level?

1	
2	
3	
4	
5	✓

d. How important do you consider science/chemistry outreach work to be for girls?

1	
2	
3	
4	
5	✓

e. How important do you consider science/chemistry outreach work to be for boys?

1	
2	
3	
4	
5	✓

f. How important do you consider science/chemistry outreach work to be for pupil premium students?

1	
2	
3	
4	
5	✓

5. Please indicate how you feel about the following statements by placing tick in **one space** only as follows (you will have the opportunity to comment on any of your views in Q6)

1=strongly disagree, 2=disagree 3=neither disagree or agree, 4= agree, 5=strongly agree

a. "Outreach work in science/chemistry helps to enhance pupils learning in their everyday science lessons"

1	
2	
3	
4	
5	✓

b. "Science/chemistry outreach work inspires students to consider science careers they may not otherwise have thought about"

1	
2	
3	
4	
5	✓

c. "Pupils who are involved in science/chemistry outreach programmes are more likely to enjoy science"

1	✓
2	
3	
4	
5	

d. "Science/chemistry outreach work has a lasting impact on students involved within the programme"

1	
2	
3	✓
4	
5	

e. "Science/chemistry outreach work enriches the science programmes of study within my school/college"

1	
2	
3	
4	
5	

N/A

f. "Outreach programmes in science/chemistry allow pupils to experience activities they may otherwise not have the opportunities to do so"

1	
2	
3	
4	
5	✓

g. "Science/chemistry outreach work motivates students to apply to science courses at university"

1	
2	
3	✓
4	
5	

h. "Science/chemistry outreach programmes are valued as an intervention tool within schools/colleges to raise attainment in science"

1	
2	
3	✓
4	
5	

6. Drawing on any themes from the questions you have just answered, along with any other ideas; describe your thoughts about science/chemistry outreach and its place within the science classroom.
Please continue on a separate sheet if you wish.

7. Please identify any outreach programmes which **currently** operate in your school/college:
Please select all that apply

Partnership with a university	
Partnership with other school(s)	
Science/STEM clubs	
Science career fairs/advice/talks	
Trips to science fairs/shows	
Links with businesses/outside industry	
Out of school hour science sessions (evening and weekends)	
Other (please indicate):	
None	✓

7

8. Considering all science outreach programmes which occur, on average please identify how frequently these types of activities occur:

Once or twice a year	
Once a term	
Once a half term	
Every 2-3 weeks	
Every week	
Never	✓

9. The following questions are designed to gather some data about yourself. Please complete by placing **one** tick in the box of each question.

a. Gender:

Male	
Female	✓
Other	
Prefer not to say	

b. Which type of institute do you **currently** teach in?

Primary School	✓
Middle School	
Secondary School	
Secondary School with a 6th form college	
All through school	
6th form centre/college	

State funded School	
Independent School	
Academy	
Free school	
Other	

c. How long have you been qualified as a teacher?

Less than a year	
1 or 2 years	
3 or 4 years	
5 or above years but less than 10	✓
10 or above years but less than 20	
20 or above years	

d. How long have you been teaching?

Less than a year	
1 or 2 years	
3 or 4 years	
5 or above years but less than 10	✓
10 or above years but less than 20	
20 or above years	

10. Are you happy to be contacted about being involved in further research in this area?

Yes	
No	✓

If yes, which school do you currently teach at:____________________________

Please provide your name:____________________________

Please provide an email/contact address:

____

LIVERPOOL JOHN MOORES UNIVERSITY School of Education

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BEFORE YOU START

If you would rather complete this questionnaire online please visit https://ljmu.onlinesurveys.ac.uk/teachers-perceptions-of-chemistryscience-outreach-work-2 **or you can scan the following QR code**

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(RSC, *Campaigning and Outreach for educators,* 2016)
http://www.rsc.org/campaigning-outreach/outreach/educators/

The following questions are designed to explore your own views of what these types of programmes involve and how useful you perceive them to be. In each question you are asked about science/chemistry outreach work as 'chemistry' as a discipline may not be taught explicitly.

LIVERPOOL JOHN MOORES UNIVERSITY School of Education

QUESTIONS

1. Please indicate the educational level(s) of science you teach *(please select all that apply)*

KS1	
KS2	
KS3	✓
KS4	✓
KS5	✓

2. Please describe your understanding of 'science outreach work'
You may provide any examples of this type of work and where it may takes place, please continue on a separate sheet if you wish.

- Events /visits from universities/ employers /industry that give experience /information to students in schools /sixth forms /colleges.

3. Please indicate what you consider to be part of science/chemistry outreach programmes:
Please select all that apply

Science/STEM Clubs	✓	Science shows	✓
Visits to Universities	✓	Links with local industry	✓
Science Fairs	✓	Extension work in science	
Extra homework		Guest speakers	✓
Placements	✓	Science careers day	✓
Science competitions	✓	Other	

4. Regardless of the current level which you teach, please complete the following by placing a tick in **one space** only as follows:

1=Not at all, 2=very little, 3=a little, 4= quite a lot, 5=a great deal

a. How important do you consider science outreach work to be at primary school level?

1	
2	
3	✓
4	
5	

b. How important do you consider science/chemistry outreach work to be at secondary school level?

1	
2	
3	
4	✓
5	

c. How important do you consider chemistry outreach work to be at sixth form/college level?

1	
2	
3	
4	
5	✓

d. How important do you consider science/chemistry outreach work to be for girls?

1	
2	
3	
4	
5	✓

e. How important do you consider science/chemistry outreach work to be for boys?

1	
2	
3	
4	
5	✓

f. How important do you consider science/chemistry outreach work to be for pupil premium students?

1	
2	
3	
4	
5	✓

5. Please indicate how you feel about the following statements by placing tick in **one space** only as follows (you will have the opportunity to comment on any of your views in Q6)

1=strongly disagree, 2=disagree 3=neither disagree or agree, 4= agree, 5=strongly agree

a. "Outreach work in science/chemistry helps to enhance pupils learning in their everyday science lessons"

1	
2	
3	✓
4	
5	

b. "Science/chemistry outreach work inspires students to consider science careers they may not otherwise have thought about"

1	
2	
3	
4	
5	✓

c. "Pupils who are involved in science/chemistry outreach programmes are more likely to enjoy science"

1	
2	
3	
4	✓
5	

d. "Science/chemistry outreach work has a lasting impact on students involved within the programme"

1	
2	
3	
4	✓
5	

e. "Science/chemistry outreach work enriches the science programmes of study within my school/college"

1	
2	
3	✓
4	
5	

f. "Outreach programmes in science/chemistry allow pupils to experience activities they may otherwise not have the opportunities to do so"

1	
2	
3	
4	
5	✓

g. "Science/chemistry outreach work motivates students to apply to science courses at university"

1	
2	
3	
4	✓
5	

h. "Science/chemistry outreach programmes are valued as an intervention tool within schools/colleges to raise attainment in science"

1	
2	
3	✓
4	
5	

6. Drawing on any themes from the questions you have just answered, along with any other ideas; describe your thoughts about science/chemistry outreach and its place within the science classroom.
Please continue on a separate sheet if you wish.

- Outreach encourages ~~[illegible]~~ students to consider certain routes in higher education / industry.
- Provides good insight for students into what university / working in industry is like.

7. Please identify any outreach programmes which **currently** operate in your school/college:
Please select all that apply

Partnership with a university	
Partnership with other school(s)	
Science/STEM clubs	✓
Science career fairs/advice/talks	✓
Trips to science fairs/shows	
Links with businesses/outside industry	
Out of school hour science sessions (evening and weekends)	
Other (please indicate):	
None	

8. Considering all science outreach programmes which occur, on average please identify how frequently these types of activities occur:

Once or twice a year	✓
Once a term	
Once a half term	
Every 2-3 weeks	
Every week	
Never	

9. The following questions are designed to gather some data about yourself. Please complete by placing **one** tick in the box of each question.

a. Gender:

Male	✓
Female	
Other	
Prefer not to say	

b. Which type of institute do you **currently** teach in?

Primary School	
Middle School	
Secondary School	
Secondary School with a 6th form college	
All through school	
6th form centre/college	✓

State funded School	
Independent School	
Academy	
Free school	
Other	✓

c. How long have you been qualified as a teacher?

Less than a year	
1 or 2 years	
3 or 4 years	
5 or above years but less than 10	✓
10 or above years but less than 20	
20 or above years	

d. How long have you been teaching?

Less than a year	
1 or 2 years	
3 or 4 years	
5 or above years but less than 10	✓
10 or above years but less than 20	
20 or above years	

10. Are you happy to be contacted about being involved in further research in this area?

Yes	✓
No	

Online screen shots

Response ID	Completion date
246429-246422-20451110	21 Feb 2017, 08:27 (GMT)

1	I have read the information sheet provided and I am happy to particpate. I understand that by completing this questionnaire I am consenting to be part of the research study and for my data to be used as described.	Yes
2	Please indicate the educational level(s) of science you teach (please select all that apply)	• KS3 • KS4 • KS5
3	Please describe your understanding of 'science outreach work'. You may provide any examples of this type of work and where it may takes place.	Out sourced members of the scientific community coming into schools or providing support to inspire the next generation of learners.
4	Please indicate what you consider to be part of science/chemistry outreach programmes: Please select all that apply	• Science/STEM Clubs • Guest speakers • Science careers day • Visit to universities • Science fairs • Placements • Science Competitions • Science Shows
5	How important do you consider science outreach work to be at primary school level?	5
6	How important do you consider science/chemistry outreach work to be at secondary school level?	5

7	How important do you consider chemistry outreach work to be at sixth form/college level?	5
8	How important do you consider science/chemistry outreach work to be for girls?	5
9	How important do you consider science/chemistry outreach work to be for boys?	5
10	How important do you consider science/chemistry outreach work to be for pupil premium students?	5
11	"Outreach work in science/chemistry helps to enhance pupils learning in their everyday science lessons"	5
12	"Science/chemistry outreach work inspires students to consider science careers they may not otherwise have thought about"	5
13	"Pupils who are involved in science/chemistry outreach programmes are more likely to enjoy science"	5
14	"Science/chemistry outreach work has a lasting impact on students involved within the programme"	5
15	"Science/chemistry outreach work enriches the science programmes of study within my school/college"	4
16	"Outreach programmes in science/chemistry allow pupils to experience activities they may otherwise not have the opportunities to do so"	5
17	"Science/chemistry outreach work motivates students to apply to science courses at university"	5
18	"Science/chemistry outreach programmes are valued as an intervention tool within schools/colleges to raise attainment in science"	5

19	Drawing on any themes from the questions you have just answered, along with any other ideas; describe your thoughts about science/chemistry outreach and its place within the science classroom.	Outreach in science provides the pupils with the context to become inspired by their current learning.
20	Please identify any outreach programmes which currently operate in your school/college: Please select all that apply	• Partnership with a university • Science/STEM clubs • Out of school hour science sessions (evening and weekends)
20.a	If you selected Other, please specify:	
20.b	Considering all science outreach programmes which occur in your school, on average please identify how frequently these types of activities occur:	Once a half term
21	What is your gender?	Male
22	Which type of institute do you currently teach in?	Secondary school with a 6th form
23	Which type of institute do you currently teach in?	Academy
24	How long have you been qualified as a teacher?	3 or 4 years
25	How long have you been teaching?	3 or 4 years
26	Are you happy to be contacted about being involved in further research in this area?	No

Ethics approval notification Phase 2 (focus group)

Ethics PR - Approved - Brennan - EDN - REF: 18/EDN/006

Dear Victoria

With reference to your application for Ethical Approval

18/EDN/006 - Victoria Brennan - PGR - Teachers' perception of chemistry outreach work as a sustainable intervention tool which can have a lasting impact; particularly with pupils from a lower socio-economic background. (Dr Andrea Mallaburn / Dr Linda Seton)

UREC decision: Approved

The University Research Ethics Committee (UREC) has considered the above application by proportionate review. I am pleased to inform you that ethical approval has been granted and the study can now commence.

Approval is given on the understanding that:

- any adverse reactions/events which take place during the course of the project are reported to the Committee immediately by emailing researchethics@ljmu.ac.uk;
- any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately emailing researchethics@ljmu.ac.uk;;
- the LJMU logo is used for all documentation relating to participant recruitment and participation eg poster, information sheets, consent forms, questionnaires. The LJMU logo can be accessed at http://www2.ljmu.ac.uk/corporatecommunications/60486.htm

Where any substantive amendments are proposed to the protocol or study procedures further ethical approval must be sought (https://www2.ljmu.ac.uk/RGSO/93205.htm)

Applicants should note that where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

Please note that ethical approval is given for a period of five years from the date granted and therefore the expiry date for this project will be **13th March 2023**. An application for extension of approval must be submitted if the project continues after this date.

Yours sincerely

Charlotte Mclean

LIVERPOOL JOHN MOORES UNIVERSITY
Charlotte Mclean, BA (Hons), MSc
PR REC Manager
(Research Ethics and Governance)
Research and Innovation Services
Exchange Station, Tithebarn Street,
L2 2QP
c.n.mclean@2014.ljmu.ac.uk

Questionnaire Participant Information sheet

LIVERPOOL JOHN MOORES UNIVERSITY

Title of Project: *Teachers' perception of chemistry outreach work as a sustainable intervention tool which can have a lasting impact; particularly with pupils from a lower socio economic background.*

Name of Researcher and School/Faculty

My name is Victoria Brennan and I am a PhD student within the School of Education, Faculty of Education, Health and Community at Liverpool John Moores University. You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Please ask if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

1. What is the purpose of the study?

This study wishes to explore teacher's views about science/chemistry outreach programmes and whether this type of work can have a lasting impact, particularly when it comes to students' choices post-16. Even though the initial focus is to look at chemistry outreach work, it is acknowledged that at primary level, or where schools do not teach science separately then these programmes may not be delivered as 'pure chemistry'. All experiences and views of science outreach work are valued as part of this study, as it these views that will assist in providing a 'better model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

Teachers from randomly selected schools in the north-west of England will be asked to participate in this study. At primary level all teachers are invited to participate, whereas at secondary and tertiary level these will only be distributed to general science/chemistry teachers.

2. Am I eligible to take part?

Teachers from randomly selected schools in the north-west of England will be asked to participate in this study. At primary level all teachers are invited to participate, whereas at secondary and tertiary level these will only be distributed to general science/chemistry teachers.

3. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive.

4. What will happen to me if I take part?

The questionnaire should take about 10 minutes to complete. Most of the questions are closed and ask you to tick a box, there are only a few questions which ask you to complete freely.

The final question will ask you whether you are happy to be involved in the next stage of the study which involves a face-to-face interview. Even, if you are happy to provide further contact details this does not mean you are committing to be involved within the next stage of this study. It may also be that due to selection criteria of the next stage you may not in fact be eligible to continue in this study.

5. Are there any risks / benefits involved?

Participation in the questionnaire stage will provide valuable insight into teacher's perceptions of science/chemistry outreach programmes.

There are no perceived risks involved when completing this questionnaire.

6. Will my taking part in the study be kept confidential?

All of the complete questionnaires will be stored in a secured, lockable location whereby no personal data will be shared. Each completed script will be coded and no personal details, including name of the school, will appear in the research paper. If you are concerned about any aspects of confidentiality before you start the questionnaire, or during the process please do not hesitate to ask any questions. Additionally, if you have any concerns about your involvement after the event you are free to contact either myself, the researcher, my Director of Studies Dr Andrea Mallaburn or the ethics committee.

This study has received ethical approval from LJMU's Research Ethics Committee *16/TPL/013* approved on the 21st December 2016

Contact Details of Researcher:

Victoria Brennan

Room H003 Holmefield House
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD
Email: V.K.Brennan@2016.ljmu.ac.uk

Contact Details of Academic Supervisor:

Dr Andrea Mallaburn
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD
Telephone: 0151 231 5380/5259
Email: A.Mallaburn@ljmu.ac.uk

If you any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

LIVERPOOL JOHN MOORES UNIVERSITY

Title of Project: *Teachers' perception of chemistry outreach work as a sustainable intervention tool which can have a lasting impact; particularly with pupils from a lower socio economic background.*

Name of Researcher and School/Faculty
My name is Victoria Brennan and I am a PhD student within the School of Education, Faculty of Education, Health and Community at Liverpool John Moores University. You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Please ask if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

1. What is the purpose of the study?

This study wishes to explore teacher's views about science/chemistry outreach programmes and whether this type of work can have a lasting impact, particularly when it comes to students' choices post-16. Even though the initial focus is to look at chemistry outreach work, it is acknowledged that at primary level, or where schools do not teach science separately then these programmes may not be delivered as 'pure chemistry'. All experiences and views of science outreach work are valued as part of this study, as it these views that will assist in providing a 'better model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

2. Am I eligible to take part?
At this stage your will have indicated that you are happy to continue your involvement in this study. If you also indicated that science/chemistry outreach programmes currently operate in your schools/colleges you are eligible to continue to this next stage. If multiple teachers replied from your school then you will have been randomly selected as only one teacher from each school is required to continue onto this second stage.

3. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive.

4. What will happen to me if I take part?

The interview should take up to 30 minutes to complete. Most of the questions are closed and therefore will only require a short response. There are then three questions in which you are encouraged to talk openly about the topics. Your responses will be recorded using voice recording equipment.

The final question will ask you whether you are happy to be involved in the next stage of the study. This involves a more in-depth process whereby further information is gathered about the science/chemistry outreach work in your school over a longer period of time. Your answer to this question will not impact on your involvement in any other stages of the study. Even, if you are happy to provide further contact details this does not mean you are committing to be involved within the next stage of this study. It may also be that due to selection criteria of the next stage you may not in fact be eligible to continue in this study.

5. Are there any risks / benefits involved?

There are no perceived risks involved as part of this study and participation in the interview stage will provide further insight into teacher's perceptions of specific science/chemistry outreach programmes. As a token of appreciation for being involved in this stage of the study I would like to provide a set of 'Horrible Science' books which can be utilised as you so wish.

6. Will my taking part in the study be kept confidential?

All of the interview transcripts and recordings will be stored in a secured, lockable location whereby no personal data will be shared. Each completed script will be coded and no personal details, including name of the school, will appear in the research paper. If you are concerned about any aspects of confidentiality or the idea of recording the interview before you start the interview, or during the process please do not hesitate to ask any questions. Additionally, if you have any concerns about your involvement after the event you are free to contact either myself, the researcher, my Director of Studies Dr Andrea Mallaburn or the ethics committee.

This study has received ethical approval from LJMU's Research Ethics Committee *16/TPL/013* approved on the 21st December 2016

Contact Details of Researcher:
Victoria Brennan
Room H003 Holmefield House
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD
Email: V.K.Brennan@2016.ljmu.ac.uk

Contact Details of Academic Supervisor:
Dr Andrea Mallaburn
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD
Telephone: 0151 231 5380/5259
Email: A.Mallaburn@ljmu.ac.uk

If you any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

LIVERPOOL JOHN MOORES UNIVERSITY
GATEKEEPER INFORMATION SHEET
Stage 3 (Focus groups)

Title of Project: *Teachers' perceptions of engagement with science outreach work, especially in the context of a child's socio-economic status.*

Name of Researcher and School/Faculty

My name is Victoria Brennan and I am a PhD student within the School of Education, Faculty of Education, Health and Community at Liverpool John Moores University.

1. What is the reason for this information sheet?

This information sheet explains what will be involved if you agree to your organisation being part of this ethnographic study for my PhD research.

2. What is the purpose of the study/rationale for the project?

This study wishes to explore teacher's views about science outreach programmes and your reasons for engaging with these initiatives. It will also focus upon whether this type of work can have a lasting impact, particularly when it comes to disadvantaged students. All experiences and views of science outreach work are valued as part of this study, as it these views that will assist in providing a 'more sustainable model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

3. What will taking part involve?

As the head teacher of the school you are identified as the person who can grant overall consent to your school's participation within the study. Once this has been granted if you could then provide the details of individual teaching staff (or the head of science/science co-ordinator) to contact to seek individual consent and find out more about these programmes. The research activities will involve focus groups with staff involved. These activities would take place during the science outreach programmes and then at a time most convenient to you and your staff; possibly during school hours but only when appropriate and outside of teaching hours. All research activities will take place on school premises.

A focus group would be designed to find out about teacher's views of outreach and share their thoughts on the design of a model that has been generated using literature and questionnaire data from previous studies. These would involve all teaching staff willing to attend.

4. Why do I need to conduct a focus group?

As a researcher, I hope to gain a deeper understanding of the science outreach activities experiences in your school.

5. How will I use the information gathered in the study?
I will use the information to outline what the benefits and limitations are when it comes to engaging with science outreach programmes and use your teacher's views to provide a 'sustainable' model of how these activities may be coordinated, with a particular focus upon the 'disadvantaged' learner.

6. Are there any benefits for taking part in this study?
As well as being able to share the findings of my study which may inform your further engagement with science outreach programmes, I would also like to provide your school a physical token of my appreciation that is intended to enhance the current science provisions in that school. These will only be presented after the completion of the focus group.

7. Will the name of the organisations taking part in the study be kept confidential?
No names will be used in my PhD thesis or any reports you request. Your school and staff will remain anonymous at all times.

8. If you are willing to assist in the study, what happens next?
If you are interested in helping me with this part of my project, please could you sign the **Gatekeeper Consent Form or written consent** provided and return to me at:
I.M. Marsh Campus (Room M105), Barkhill Road, Liverpool, L17 6BD. Or you can email myself using the address identified below.
Alternatively, passing this information on to the relevant staff will imply informed consent.

I am also willing to visit your school/college to explain my research in further detail and collect the consent form.

Should you have any comments or questions regarding this research, you may contact:
Victoria Brennan (PhD student): V.k.brennan@2016.ljmu.ac.uk or my Director of Studies, Dr Andrea Mallaburn: a.mallaburn@ljmu.ac.uk , 0151 231 5380

This study has received ethical approval from LJMU's Research Ethics Committee (18/EDN/006: received on the 13/03/2018)
Should you have any comments or questions regarding this research, you may contact the researchers:

Contact Details of Researcher
Victoria Brennan
Room H105 Holmefield House
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD

t.0151 2315348
Email: V.K.Brennan@2016.ljmu.ac.uk

Contact Details of Academic Supervisor:

Dr Andrea Mallaburn
I.M.Marsh
Barkhill Road
Liverpool
L17 6BD
Telephone: 0151 231 5380/5259
Email: A.Mallaburn@ljmu.ac.uk

If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person

LIVERPOOL JOHN MOORES UNIVERSITY

PARTICIPANT INFORMATION SHEET

Participant Information Sheet for Focus Group:
Teachers' perceptions of engagement with science outreach work, especially in the context of a child's socio-economic status.

You are being invited to take part in a Focus-Group interview as part of a wider PhD research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please do ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Name of Researcher and School/Faculty

My name is Victoria Brennan and I am a PhD student within the School of Education, Faculty of Education, Health and Community at Liverpool John Moores University. You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Please ask if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

What is the purpose of the study?

This study wishes to explore teacher's views about science outreach programmes and your reasons for engaging with these initiatives. It will also focus upon whether this type of work can have a lasting impact, particularly when it comes to disadvantages students. All experiences and views of science outreach work are valued as part of this study, as it these views that will assist in providing a 'better model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

Why have I been chosen?

You have been chosen due to your school's engagement with difference science outreach initiatives.

Do I have to take part?

Completion of the focus group is entirely voluntary. Your decision to participate or not will not provide any advantage or disadvantage to you. You are still free to withdraw at any time and without giving a reason. We would, however, greatly appreciate you taking the time to participate.

What will happen to me if I agree to take part?]You will confirm whether you are willing to participate in the Focus group. A date and time will then be arranged dependent upon your availability. It is expected that the focus group should take no more than one hour to complete. Your completion of the informed consent form will be taken as your consent to participate in the research and your responses will be recorded using voice recording equipment.

Are there any risks / benefits involved?
There are no perceived risks involved as part of this study and participation in the focus group will provide further insight into teacher's perceptions of specific science/chemistry outreach programmes and their delivery. As a token of appreciation for being involved in this stage of the study I would like to provide some science resources after the completion of the focus group for the school to be able to use in future.

Who is organising and funding the research?
This research is being funded LJMU.

What will happen to the results of the research study?
The results will be analysed by the researcher detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed**. Reference to specific people, who you may mention, will also be removed from any quotations that are used. Recordings will be kept on a secure password protected LJMU M drive and once transferred from the device to the M drive will be deleted from said device. The M drive will also include coding sheets and other identifying data such as Pseudonyms. Your anonymity is important in this study. Your signed consent forms will be stored in a locked filing cabinet on the LJMU premises.

What if something goes wrong?
If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Andrea Mallaburn- a.mallaburn@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved
This research has been ethically approved (18/EDN/006: received on the 13/03/2018).

Contact details
If you have any questions then please feel free to email Victoria Brennan on V.k.brennan@2016.ljmu.ac.uk

Thank you for taking the time to read this Participant Information Sheet

APPENDIX F: PHASE ONE CODING FRAME AND CODEBOOK

Questionnaire coding framework

Question Code	Identifier
Q1	***Educational levels you teach***
1	KS1
2	KS2
3	KS3
4	KS4
5	KS5
Q2	***Describe your understanding of science outreach work***
1-Yes	Engagement and inspiration
2-No	Hands-on and using new resources
	Wider knowledge of science
	Application of science in real life
	Teacher CPD
	Involves an external party
Q3	***Indicate what you consider to be part of science outreach programmes***
1-Yes	Science/Stem Clubs
2-No	Visits to Universities
	Science Fairs
	Extra homework
	Placements
	Science Shows
	Links with local industry
	Extension work in science

	Guest speakers
	Science Careers Day
	Other
Q4a	***'How important do you consider science outreach work to be at primary school level?***
1	Not at all
2	Very little
3	A little
4	Quite a lot
5	A great deal
Q4b	***'How important do you consider science outreach work to be at secondary school level?***
1	Not at all
2	Very little
3	A little
4	Quite a lot
5	A great deal
Q4c	***'How important do you consider science outreach work to be at sixth form/college level?***
1	Not at all
2	Very little
3	A little
4	Quite a lot
5	A great deal
Q4d	**'How important do you consider science outreach work to be for girls?**
1	Not at all

2	Very little
3	A little
4	Quite a lot
5	A great deal
Q4e	***'How important do you consider science outreach work to be for boys?***
1	Not at all
2	Very little
3	A little
4	Quite a lot
5	A great deal
Q4f	***'How important do you consider science outreach work to be for pupil premium students***
1	Not at all
2	Very little
3	A little
4	Quite a lot
5	A great deal
Q5a	***"Outreach work in science helps to enhance pupils learning in their everyday life"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5b	***"Science outreach work inspires students to consider science careers that they may not otherwise have thought about"***
1	Strongly disagree

2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5c	***"Pupils who are involved in science outreach programmes are more likely to enjoy science"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5d	***"Science outreach work has a lasting impact on students involved within the programme"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5e	***"Science outreach work enriches the science programmes of study within my school/college"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree

Q5f	***"Outreach programmes in science allow pupils to experience activities they may otherwise not have the opportunities to do so"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5g	***"Science outreach motivates students to apply to science courses at university"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q5h	***"Science outreach programmes are valued as an intervention tool within school/colleges to raise attainment in science"***
1	Strongly disagree
2	Disagree
3	Neither disagree or agree
4	Agree
5	Strongly agree
Q6	***Describe your thoughts on science outreach and its place within the science classroom***
1-Yes	Engagement and inspiration
2-No	Hands-on and using new resources
	Wider knowledge of science
	Application of science in real life

	Teacher CPD
	Involves an external party
	Assists learning within the curriculum
	Logistics of engaging with outreach
	Supports different groups of learners
Q7	***Please identify any outreach programmes which <u>currently</u> operate in your school/college.***
1-Yes	Partnership with a university
2-No	Partnership with other school(s)
	Science/STEM clubs
	Science career fairs/advice /talks
	Trips to science fairs/shows
	Links with businesses/outside industries
	Out of hour science sessions (evening and weekends)
	Other (please indicate)
	None
Q8	***On average how often do these science outreach events occur?***
1	Once or twice a year
2	Once a term
3	Once a half-term
4	Every 2-3 weeks
5	Every week
6	Never
Q9a	***What is your gender?***
1	Male
2	Female

3	Other
4	Prefer not to say
Q9bi	***Which school level do you work in?***
1	Primary School
2	Middle School
3	Secondary School
4	Secondary school with a 6^{th} form college
5	All through school
6	6^{th} form centre/College
Q9bii	***Which type of school do you work in?***
1	State Funded School
2	Independent School
3	Academy
4	Free school
5	Other
Q9c	***How long have you been qualified as a teacher***
1	Less than a year
2	1 or 2 years
3	3 or 4 years
4	5 or above years but less than 10
5	10 or above years but less than 20
6	20 or above years
Q9d	***How long have you been teaching?***
1	Less than a year
2	1 or 2 years
3	3 or 4 years

4	5 or above years but less than 10
5	10 or above years but less than 20
6	20 or above years
Q10	***Are you happy to be contacted about being involved in future research in this area?***
1	Yes
2	No
For all questions the code 99 means no response was provided	

Coding sheet description stage 1

Links to literature	High order themes	Tertiary theme	Description	Raw data quotes
Cridge and Cridge (2015)[a]	Outreach work inspires learners and promotes engagement and confidence in science.	Enthuse and engage Inspiration and motivation Confidence in science	Any reference to students being engaged and enthused in science. Any reference to providing inspiration. Any references that suggests students feel more confident about science.	"It is most important to enthuse children about science." Participant 18P "Engages thinking about the 'big ideas'." Participant 19S "Outreach in science provides the pupils with the context to become inspired by their current learning." Participant 10S "Inspiration and motivation." Participant 35P "Give pupils more confidence in their abilities on the subject." Participant 22S "Confidence to apply for level 3 courses." Participant 34S
	Outreach allows hands-on access to different resources and types of activities.	Access to resources not available in schools. Provides unique	Suggestions that it allows students to experience activities that would not happen in an everyday classroom.	"This is an opportunity for students to experience other styles of teaching and practical activities that may otherwise be unavailable in a school environment." Participant 14S "It helps children to engage through stimulating activities that are usually difficult to deliver in a classroom setting." Participant 38P

		hands on experiences.	Reference to outreach being 'hands-on'	"This is an opportunity for students to experience other styles of teaching and practical activities that may otherwise be unavailable in a school environment." Participant 14S "It should provide something different/more exciting/more dynamic or more detailed than an 'ordinary' lesson or teacher of primary science can provide." Participant 42P
	Outreach provides a wider knowledge of careers available in science.		Reference to how outreach can allow students to find out about different careers available in science.	"Making school science more relevant to the world of work." Participant 7S "Great to give alternative career ideas". Participant 32S "It encourages children to think more about how they could achieve a career in science." Participant 35P
	Outreach work shows how science is applied in a real-life context.	Places learning science in context. Exemplifies applications of science.	Any reference to science in context. Any reference to the uses of science in everyday life.	"Science outreach is essential if students are going to see the links to the wider world." Participant 12A "Important to raise profile of science and its relevance to life outside/beyond education." Participant 33S "Any activity that gets pupils/student applying/linking their scientific knowledge must be worthwhile." Participant 6S "It takes the learning outside the limits of the classroom and into the real world. This make the learning relevant to the students and makes it something that the students remember." Participant 11S
Gumaelius *et al* (2016)[a]	Science outreach involves external partners	Inbound experience Outbound experiences	Any description of a person or organisation visiting the school to deliver an outreach activity. Any description of students visiting another location (outside of school) to engage with science activities.	"Out sourced members of the scientific community coming into schools". Participant 10S "Clubs or expert providers who come in to schools to help develop science in class and with teachers." Participant 20P "Taking students to university and industry to see career pathways and application of their learning." Participant 39F "Science work outside of the classroom eg. field trips" Participant 23S

	Outreach includes continued professional development (CPD) for teachers'		Reference to how science outreach work may support teacher development.	"Career fairs, work experience placements, up to date training/support for teachers." Participant 3S "Science teachers that have been in post for many years might not have the knowledge of recent developments that could enhance the teaching and motivation of the pupils." Participant 7S "Supports teacher CPD and confidence." Participant 20P
Shaw *et al* (2010)[b]	Science Outreach assists with learning in the curriculum.		Any reference to outreach activities supporting formal learning that is prescribed by the curriculum.	"Outreach in science provides the pupils with the context to become inspired by their current learning." Participant 10S "When well organised, outreach programmes are a valuable part of an extended curriculum." Participant 27S "We have had a number of organisations visit our school over the past 10 years. All experiences have excited our children and supported teaching and learning." Participant 37P
Goodman (2002)[b]	Issues related to the logistics and design of delivering outreach work.		Any reference to the design or cost (either time or financially) of engaging with outreach in science.	"It is an excellent motivational tool if used effectively with the right students" Participant 15S "There is a lack of interest within chemistry because not every school can show it at its full potential due to lack of funding and timing due to the new courses having too much information." Participant 47S "It is a great thing. It needs to be more thought out and to be embedded in the schemes of work and integrated into the curriculum." Participant 5S
Shanahan *et al* (2011)[b]	Science outreach is able to support and enthuse specific groups of learners.		Reference to how outreach worm may be particularly useful for particular types of students.	"Any activity which engages 'non-scientists' in a scientific activity." Participant". Participant 26S "…can increase interest or extend higher ability pupils". Participant 13S
Glover *et al* (2016)[b]	The impact of outreach work is dependent on each particular student.		Suggestion that science outreach work may appeal to some students and not to others.	"It could enhance the experience of science learning for those interested and maybe ignite the interest of those who aren't interested." Participant 9S "It is very pupil dependent. If a pupil already has a strong interest and career pathway in science/another subject it has no impact. Equally if a pupil has no interest in science it has no worth." Participant 23S

				"It can motivate but depends upon whether the students involved are enthusiastic ie. Volunteered/selected/optional/obligatory." Participant 28S

[a] Themes predetermined by the literature
[b] Inductive – emergent themes

Code book from NVivo Stage 1 and 2 combined

Name	Description	Sources	References
Involving parents		1	1
Logistics, design and delivery of science outreach programmes	Any reference to the design, delivery or cost (either time or financially) of engaging with outreach in science.	21	34
Cost of outreach		8	22
Establishing a partnership		5	8
Location		2	7
The training and background of those delivering the sessions		5	10
Time		4	8

Which students engage with these outreach activities	Examples of different students experiencing various outreach programmes.	5	10
Negative feelings linked to science outreach programmes	Teachers' views of any negative impact outreach may have on their pupils whom experience these programmes.	4	10
Outreach allows hands-on access to different resources and types of activities.	See node descriptions	22	47
Access to resources not available in schools	Suggestions that it allows students to experience activities that would not happen in an everyday classroom	17	18
Provides unique hands on experiences.	Reference to outreach being 'hands-on'	12	14
Outreach includes continued professional development (CPD) for teachers'	Reference to how science outreach work may support teacher development.	9	11
Outreach provides a wider knowledge of careers available in science.	Reference to how outreach can allow students to find out about different careers available in science.	22	32
Outreach work shows how science is applied in a real-life context.	See node descriptions	16	21
Exemplifies applications of science.	Any reference to the uses of science in everyday life.	10	11

Places learning science in context.	Any reference to science in context.	9	9
Positive impact on students who engage with science outreach programmes	See each node	34	69
Confidence in science	Any references that suggests students feel more confident about science.	5	5
Encourages progression in formal education		4	5
Enthuse and engage in science	Any reference to students being engaged in science.	16	18
Helps with future decisions		4	9
Improves general life skills		1	2
Inspiration and motivation in science	Any reference to providing inspiration.	18	18
Science Outreach activities to raise aspirations		6	8
Science outreach involves external partners	Indication of another organisation supporting learning in science.	44	73
Inbound experiences	Any description of a person or organisation visiting the school to deliver an outreach activity.	25	32
Online learning platforms		2	2

Science club		2	6
Science competition		2	2
Science speaker		6	11
Science workshops		5	8
Theatre group		1	1
Industry partnership		3	3
Outbound experiences	Any description of students visiting another location (outside of school) to engage with science activities.	20	22
Trip to a museum or learning centre		4	7
Trip to a science fair or conference		2	3
Visit to other school		2	3
Visit to university		2	3
Science outreach to support learning in the classroom	see each code	2	4

Science Outreach assists with learning in the curriculum.	Any reference to outreach activities supporting formal learning that is prescribed by the curriculum.	20	27
Science outreach is able to support and enthuse groups of learners.	Reference to how outreach worm may be particularly useful for particular types of students.	5	5
Suggestions of improving science outreach provisions		7	14
Teachers' perceptions of the impact of students engaging with outreach work	See each code	0	0
The impact of outreach work is dependent on each particular student.	Suggestion that science outreach work may appeal to some students and not to others.	8	10
The lasting impact of science outreach		7	9
Teacher's perceptions of the importance of science in the curriculum	Teachers' views of their colleague’s attitudes towards science.	5	11

Appendix G: Interview Schedule

Introduction			
• Introduce myself • Many thanks for agreeing to participate in the follow up questions about science/outreach programmes in your school. • Purpose of the project: - Collect detailed information about outreach programmes which currently exist in a range of school settings. - Gain a brief insight into teachers' views about these schemes running in their schools and depict their thoughts about what does work well and what doesn't work well in terms of the outreach work. • Throughout the questions, if you could provide as much detail as possible that would be greatly appreciated and help us to understanding the experience of sports coaches through coach education and transfer of knowledge into applied coaching practice.			
Q Aim	**Q style**	**Question**	**Rationale**
SPECIFIC DETAIL OF OUTREACH PROGRAMME	Structured/recording schedule	1. a. What science/chemistry outreach programme currently operates in your school? b. How often do these activities occur? c. When do these activities take place? d. Who delivers this outreach programme? e. Where does this outreach programme take place? f. What type of activities usually occur during this programme? g. On average, how many pupils are involved in this programme? h. Is this programme voluntary? i. Is this programme open to all students? j. Does this programme incur a cost to the school?	The first 2 questions are the same were on the questionnaire, however, it is important these are repeated to ensure that the information provided was correct and to ensure the participant is focused on the theme of the interview. The other questions are closed in nature and are designed to gather information in a succinct manner. The range of questions aim to explore who delivers the programme, when and where it happens, who participates and the costs involved. It essentially wishes to explore the pragmatic areas of the programme as way of informing the next stage of the study.

		k. Do the pupils have to contribute financially to this programme? l. Is the programme differentiated? m. Does this outreach work link to the curriculum which you follow? n. Does this programme highlight any future career opportunities? o. Does this programme use any specialist equipment that is not readily available at school?			
			Possible prompts	**Follow up questions**	**Rationale**
PERCEIEVED BENEFITS OF THIS	Semi-structured	2. Can you describe what you think the benefits are of this programme and how it may positively affect the pupils whom attend?	In what way? How? Why? Could you provide any specific examples of these advantages	What do you and your students gain from this programme? Are the benefits long lasting?	To gain an insight into the teacher's perceptions of the positive aspects of this programme.
PERCEIVED LIMITATIONS OF THIS PROGRAMME	Semi-structured	3. Can you describe what you think the limitations are of this programme and how it may negatively affect the pupils whom attend?	In what way? How? Why? Could you provide any specific examples of these disadvantages?	Is there a way to eliminate these negative points? Do you think the students are aware of these negative aspects?	To gain an insight into the teacher's perceptions of the negative aspects of this programme.

SUGGETIONS TO IMPROVE THE	Semi-structured	4. If you were the leading this outreach programme what would you keep the same and what would you do differently? For both points, why?	How would you implement that? Why would you make that change? How would it be even better if?	How does your experience of teaching help to inform this?	This question allows the teacher to suggest specific improvements or problems of the science/chemistry outreach work they have encountered. It is there for a linking question to draw on themes of stage 3 of the project.
FUTURE ONVOLVEME NT	Structured	5. Would you be happy to be involved in the next stage of the study which would involve a longer partnership between your school at my research at LJMU?	This question is to assist with the recruitment process of the next stage of the study. It will assist with time management so that it is known whether teachers are happy to continue being involved with this research.		
Any other comments? Thank participant and remind them that their input will remain confidential and be anonymised					Gillham (2005) highlights that it is important to thank the interviewee as they have shared personal information and may feel slightly vulnerable. Thus by ensuring they are thanked this acknowledges the researcher appreciation and reassured the participant.

Appendix H: Pre-pilot Interviews notes and changes to be made

1. This was completed on Tuesday 9th May 2017 with 2 secondary science teachers whom attended the Salter's chemistry festival.
2. They were provided with the participant sheets, read through these and also signed consent forms to outline that they were happy for their responses to be used/shared.
3. It was explained what the 'bigger picture' of the research outcomes were and how their views could help to inform the study. It was also outlined that this was a pre-pilot and therefore, after answering the questions they would be asked whether they felt like they had been asked enough about outreach, what other questions they may like to ask and timings etc.
4. Question 1 is a series of 15 questions about outreach which their schools partake in. It was noted that the questions need to be changed to plural and that if there are several different outreach initiatives then maybe there should be some columns so that each question links to that particular outreach programme or it can get quite complicated.
5. Question 1 is structured to reduce the time and to be used as a data collecting activity. However, when answering the questions they often wanted to expand on the experiences. Therefore, I will consider the time of the entire interview and how to structure the prompt sheet.
6. Baring in mind these proposed changes; it is also noted that the teacher involved in this pre-pilot interview were present at an outreach event therefore, there may be several opportunities for students at their schools.
7. There was an emphasis on the opportunities for pupil premium students, most examples showed that it was different companies/universities that were delivering these programmes and that the activities involve resources that would otherwise be unavailable at school. The activities that often took place were in a workshop format and pupils were 'invited' to attend these events. A teacher described how they would never make it compulsory so that it did not 'force the students'.
8. Question 2 needs to be split into a and b sections as I feel that I was asking too much and it may have also limited the response provided.
9. The benefits of the outreach programme experienced were outlined as providing a new opportunities for pupils to learn about their possible future. A school indicated that some of their pupils had never been to a university campus before (the child's parents had not attended university also) and that it provided an insight into what they could do. It was also said that these programmes 'make science real' for the pupils When asked about whether they felt that the benefits were long lasting A said that they 'would like to think they are' but also said that as their teacher they did not do enough to follow up the activities to make if longer lasting. They also named one chemistry outreach programme which is longitudinal in nature and therefore they felt that this was has a longer lasting impact, especially as you could trach it. The teacher from school B agreed but also stated that they felt that it depended on the pupil; the individual recalled how she still remembers her science trip to a university but she was interested in science in the first place.
10. Question 3 asked two different things, therefore this needs to be split into 2 separate questions. One about the negative affect it could have on pupils and one whereby it asks about what could 'limit' a teacher's involvement with such outreach programmes. The participants when asked about any additional questions they felt that they could have been asked suggested a standalone question which asked them about why they may not

want to/be able to, get involved with the outreach activity in the first place. The splitting of these two questions would address this point made.

11. The negative aspect was something that the A teacher had not experienced but they stated that if the outreach activity was pitched at the wrong level or delivered in the wrong style then it could disengage the pupils. This would have a negative effect as if the pupil did not enjoy science but you told them that they would on this trip/event then this would 'reaffirm' their dislike for science.
12. Question 4 asked the teachers about what would they keep the same about the outreach programme of they were leading the activity. I think this needs to be made clearer if there are multiple programmes; depending on time each one could be asked about separately, or teachers would just be asked to consider the one they experience most frequently. The teachers considered the chemistry outreach programme and said they would keep the practicals, visits, assemblies and the STF the same. What they said they may do different/add to the programme is a stronger link to careers-maybe suggesting a careers fair.
13. Both participants agreed to be contacted in any future research, or if any other feedback was required form the interview.
14. When asked about the length of the interview they described how it was just right and also commented that other than the additional question outlined in point 10, they felt like they had been asked everything about their view of science/chemistry outreach.

APPENDIX I: EXAMPLE OF COMPLETED INTERVIEW SCHEDULE

IP2

KS1 - Tech ~~Request~~ gives; Tesco - Healthy food (Bio)

Highschools links - each year. Bishops Highschool

Question 1	Outreach example/response	Outreach example/response	Outreach example/response
What science/chemistry outreach programme currently operates in your school?	Science Visit (Y5) -Catalyst museum.	Tim Peak Primary Project - PSQM silver	-STEM ambassador workshops.
How often do these activities occur?	All years apart from Y6 go on a trip	STEM Club - Y6 Parent -Thurs lunch. -Y5 run club Y2.	
How often do these activities occur?		Y6 - half an hour Thurs PM Y2 - 8-10 weeks (Summer).	
When do these activities take place?		School.	
Who delivers this outreach programme?			
Where does this outreach programme take place?			
What type of activities usually occur during this programme?	Investigation Skills SSG	-Chromatography Y2 floating sinking -shapes -telephones / Y6 -Making rockets axels.	
On average, how many pupils are involved in this programme?	55-60	Y2-6-16. Y6-10.	
Is this programme voluntary?		Club-voluntary	
Is this programme open to all students?	Yes.	yes.	
Does this programme incur a cost to the school?	only if parents dont pay voluntary contributions	Initial outlay for Y2 (£100 approx)	
Do the pupils have to contribute financially to this programme?	PP-use vouchers for trips. -Voluntary contribution Depends on cost. -£10-20	No cost.	

Y6 - Residential (Bio focused)

Aspirations week - chemist visit Health week.

Want to develop links with uni. - nature trail

Is the programme differentiated?	Not really.	By outcome.	
Does this outreach work link to the curriculum which you follow?	Yes. -have to.	- loosely. - but lots of topics.	
Does this programme highlight any future career opportunities?	More aspiration.	-not Y2 -Y6- aspiration.	
Does this programme use any specialist equipment that is not readily available at school?	Yes - biggest advantage.	No.	

In chester – clusters of schools to network with → Sharing expertise

2a. Can you describe what you think the benefits are of this programme?	In what way? How? Why? Could you provide any specific examples of these advantages	What do you and your students gain from this programme?	Experiences ~~std~~ wouldn't get in lessons Expertise workplace context equipment
2b. How it may positively affect the pupils whom attend?		Are the benefits long lasting? Hope so. – MS still remember things	WOW factor – pupils remember – Pupils love of the subject generally 'love' the subject the teachers love – need to enthuse the teachers. 'WOW'.
3. How it may negatively affect the pupils whom attend?	In what way? How? Why? Could you provide any specific examples of these disadvantages?	Do you think the students are aware of these negative aspects?	Y/S – Some were scared/bangs (SEND) needs – Scared to go high school. Shocked – not in a good way.
4. Can you describe what could 'limit' a teachers involvement with particular outreach programmes? → -Curriculum restraints -Ofsted - finances		Is there a way to eliminate these negative points?	Need high school to do different activities – ~~Need~~ not as enthused – as they knew.

- not always having things available nearby.
- Not support Head.

Need staff enthused.

↳ yes can be difficult to enthuse others.

↳ lack of ~~confidence 'rubbish'~~

↳ lots of other pressures.

↳ Their own experience of science (as pupils) change their mind set.

Science ambassadors in each year. Low costs

· Set up a few years ago.

→ Could be eliminated by networking. → FB group. PSQM → £600 cost. →

			EBI	WWW EBI	
5. If you were the leading each outreach programmes that you engage with what would you keep the same and what would you do differently? For both points, why?	How would you implement that? Why would you make that change? How would it be even better if?	How does your experience of teaching help to inform this?	→ High for Primary find out what the primary school wants/needs (can be tedious) → need to link to childrens needs/interests (confidence of highschool teacher to teach primary) → Science need to to establish links to support each other	→ WOW factor → flexible → one visitor modified session based on the pupils'	
6. Would you be happy to be involved in the next stage of the study which would involve a longer partnership between your school at my research at LJMU?	Yes.				

APPENDIX J: EXAMPLE OF INTERVIEW TRANSCRIPTS

Interview form a primary school teacher

A=Interviewer
B=Interviewee

A "So, what obviously my research is, I'm looking at outreach kind of science, outreach at a variety of levels, erm, and kind of just getting your views on what you think about it really. So is there any kind of outreach, kind of science outreach programmes that operate in your school? So it can be clubs or businesses or visits etc."

B "Yeah. So we have, erm, a science club which I run, erm, which I open up to two year groups, alternative terms. So they do about six weeks and that's at the school, for an hour. Erm, that usually just involves just sort of practical science investigation type things, erm, so for example we did like making slime, things like that, just fun things to get the children engaged and enjoying science. Erm, we've had people coming in to deliver science workshops."

A "Who was it that …?"

B "We've had Education Group, they came in and delivered a fossil workshop. They brought in a dinosaur. I don't know if you've ever heard of them, they're really good."

A "That sounds great."

B "Just very expensive. Erm, we've had, what else have we had …? How many years back do you want to go or just in this year?"

A "Just kind of, like, recent, like over the last, something that you see happening again maybe as well."

B "Well we have the allotment as well, that's where the children go out and visit the allotment and that's part of their science and this year in particular I want to push it so that all year groups go to the allotment. It just used to be one year group, in Year 3."

A "Yeah. So I'm just going to go through, like, each one, I tried to fill some of those in as you went on, no, it's fine, it's great, so many things happening.

	So, going back to the science club, let's see how often, so it's six weeks, one hour and is that six weeks times two for the different year groups?"
B	"Yeah. So basically we've just done six weeks in the first term, that was Year 5 and 6 and I had about 25 children coming to that and then I will open it up again in January for that term, again for six weeks and that will be open to Year 3 and 4."
A	"And a similar amount of pupils?"
B	"Hopefully, yeah. There's always a huge amount of interest, you know, especially when they hear they're making slime [laughing] or making volcanoes explode."
A	"Where do they, where do they, obviously they take place in the school, I assume."
B	"Sorry?"
A	"They take place in the school?"
B	"School, yeah."
A	"Erm, sorry, when do they take place, is it after school?"
B	"Yes. Science club is after school, yeah."
A	"Right. Erm, so it is a voluntary programme is it for the kids?"
B	"Yeah."
A	"And is it open to all students or …?"
B	"Yeah. So across the year all students will get a chance to join in."
A	"Erm, does it cost, does it incur a cost to the school?"
B	"Yeah. Just the costs of the sort of ingredients and resources that I need. Erm, so we've spent about £50 this year but most of them resources will last most of the year if you know what I mean."
A	"Yeah and do the pupils have to contribute financially in any way?"

B “No, not for this club.”

A “No for that one. Erm, and is the programme differentiated?”

B “No.”

A “No. Erm, does the work in the outreach that you do in the science club, does it link to the curriculum?”

B “Yes. Erm, so it links to, a lot of it links to the physics elements, erm, status of matter, forces, those kind of things. Erm, so when I do 5 and 6, I know in Year 5 they do some chemistry which is like reactions and reversible and non-irreversible, sorry, erm, so I touch on all them kind of things but again it’s always like a practical sort of way but it is drawing on those topics.”

A “And would that be with all the year groups?”

B “Yeah.”

A “Yeah. Erm, does, do you kind of highlight any future career opportunities when you’re …?”

B “Talking to the kids?”

A “Yeah.”

B “Erm, not in the club really, no.”

A “Okay, that’s fine. Does it use any specialist equipment that is not readily available in school?”

B “No.”

A “Erm, so, in terms of your other example, the science works groups, it’s similar questions again. How often do activities actually occur?”

B “The workshops have been once a year basically. Erm and there was two workshops in that one in particular, the dinosaur one.”

A “Yeah and when do they take place, is it in school time?”

B	"Yes in school time, part of their lessons."
A	"Yeah. Erm, I've done that one. Er, and it takes place at school. So, or you've done the activities … I'm just looking at what you've answered. So how many pupils are usually involved in this?"
B	"In that workshop there is Year 3 which is about, erm, 60 pupils."
A	"Great. Erm, and is it voluntary, the programme?"
B	"The workshops are sort of part of their lessons so yeah they have to take part, it's not really voluntary."
A	"Erm, and is it open to all students?"
B	"Erm, that workshop in particular is just Year 3 cos it will link to their topic."
A	"Does the programme incur a cost to the school?"
B	"Yes. It costs around about £500, that workshop, yeah. Hhmmm."
A	"And do the pupils have to contribute to this?"
B	"No they didn't."
A	"That's a lot. It sounds good but …"
B	"It was good and it's the cost that stops you doing some of these things, even though you know that the outcomes are really good but budgets are really tight."
A	"Is the programme differentiated?"
B	"Erm, to a certain degree yes. Erm, when they deliver the workshops we're made aware of the children who need, who have particular needs and they cater for those needs, SEN type of needs."
A	"Yeah. Erm, does it link to the curriculum?"
B	"Yes."
A	"So you were doing the dinosaurs and fossils was it?"

B “It was part of their rocks and fossils topic in science.”

A “Erm, and does it highlight any future career?”

B “Yes. They did speak about some future opportunities, yeah.”

A “And …”

B “In particular like archaeology and things like that. Palaeontology.”

A “Things that are practical and linked to the activities?”

B “Yeah.”

A “And does it use any equipment that’s not readily available in school.”

B “Yeah. They brought some specialist equipment in, microscopes and fossils.”

A “Okay. And then the last one, the allotments. So, how often would the kids usually visit the allotment or is that …?”

B “Right, so, the allotment is happening on a weekly basis, once a week. Erm, it’s, last year it was open to Year 3, erm, as part of their science lessons. This year I’m hoping to do all years.”

A “And is it you that kind of leads this?”

B “I lead it but I expect teachers this year to do some of the activities as well.”

A “Do they, so they take place in lesson times?”

B “Yeah.”

A “Erm, what type of activities do you do at the allotment?”

B “It’s a range of activities from, you know, basic maintenance, digging and planting to planning. So planning, erm, where the beds need to go, crop rotation. We’ve got a gardener you see as well who leads us all on that. Erm, they [pause], yeah, and then the science lessons link to that you see. So Year 4, the aim this year is that the Year 4s will go over and study habitats there. It makes sense to use it. The Year 3s do plants. The Year 5s do plants and Year 6 do evolution and looking at, like, adaptations of the animals, living things, things that live in the allotment type things, that's their link."

A "That would be great. Erm, so is it voluntary or part of their …?"

B "Part of their lessons."

A "Erm, and you've kind of answered is the programme open to all? So it was open to Year 3 and now, yeah …"

B "Hopefully all years."

A "Erm, does it incur a cost to the school?"

B "Yeah. So we pay £20 an hour to the gardener and that's for two hours a week."

A "Yeah."

B "Erm, we did have a more expensive gardener last year so we tried to cut that cost, yeah. Erm, and then there's not much of a cost throughout the year. Obviously there's a little bit of cost in terms of some equipment that we have to replace every now and then, erm, and seeds, you know, plant pots and things like that but it's, it's not normally a lot, it's about £100 throughout the year. Sometimes it can be more, obviously."

A "Erm, do the students ever contribute to this cost?"

B "Erm, no."

A "No."

B "I'm just thinking cos I know one year we did sort of ask for, like, contributions in terms of, erm, we sort of like sold the fruit and veg, in a way, you know."

A "But that's kind of an end product."

B "That's enterprise, yeah."

A "Is the programme differentiated when you use the allotment?"

B	"Erm, to a certain degree in terms of catering for those special needs and things like that."
A	"Yeah. Erm and does it link to the curriculum?"
B	"Yes. It links to other subjects as well as science."
A	"And skills I imagine as well."
B	"Yeah. Lots of what we call SMSC, all those."
A	"And does it highlight any future career opportunities, would you say?"
B	"Yeah, gardening. The gardener we used last year, he did keep, you know, saying to children 'you'd be a great gardener or horticulturalist' cos that's what he technically was, so he did push that last year, it was good."
A	"There'll be a couple of kids now like 'that's what I want to do'."
B	"Yeah, 'that's what I want to be'. [laughing]"
A	"And does it use equipment not readily available at school? Have you had to buy that in?"
B	"Erm, no, I mean it's just like spades and things like that."
A	"Yeah. So thanks for that. Obviously there's a lot going on in the school and I'm assuming, are you Science Co-ordinator?"
B	"Yes."
A	"I kind of got that. Erm, so, you don't have to, like, describe all the programmes but just in general, what do you think the benefits are to some of these things that you are doing with the pupils in terms of the science, the extra science?"
B	"The extra science, like the science club and the allotment in particular, even the workshop, my aim was to get them more hands on, practical activities. There's some children that won't engage in science lessons because sometimes they can be too written based, erm, or even too much reading, you know, some of the children struggle to read even that we have. So when

they can do practical, hands on activities and they can talk, they show a lot more science understanding and knowledge."

A "Yeah and, erm, what do you think you gain from doing these, delivering these or being involved in these programmes?"

B "Cos I've done the science club, erm, I've certainly developed my knowledge in terms of, like, chemistry and the vocabulary that I'm using cos a lot of the stuff that I get is from our, erm, from our local authority user, so when I go to the science briefings, erm, he obviously gives me a lot of ideas and the vocabulary to go with them which has been really good, erm, for my own development, yeah."

A "Yeah, that sounds great. So how do you think it positively affects pupils that attend?"

B "They become more interested in science and more engaged in science. They say to me 'I can't wait to be in your class to do science', that kind of thing, just the excitement and the buzz that they get from it."

A "Yeah. And do you think the benefits are long lasting, do you think?"

B "I'd like to think so [laughing]."

A "Yeah, we all would. Erm, so kind of, kind of thinking more critically, I guess, do you think there's any, do you think there's any pupils who have negative experiences with these programmes or, erm, you know, like, pupils being involved, could it affect them in a negative way, do you think?"

B "I don't think any of the children think of it in a negative way. Erm, some of them might not be as engaged as you might hope, you might not get that same buzz from them but children respond in different ways. Erm, I can't really think of an example where they respond negatively and they've said 'I don't want to do that, I'm not interested'."

A "So you think they're always, kind of, especially when someone comes in then …?"

B "Yeah, yeah, especially when someone comes in and when they get to go to the allotment they're always keen to do that. As I said, science club has always had a massive uptake, a massive response to that."

A "So what do you think, so this is more from a teacher's perspective, what do you think you as a teacher or your colleagues would limit you from wanting to get involved in, erm, different outreach programmes? What do you think those kind of …?"

B "I think the main concerns or the main limitors are, like, cost. Is that what you mean?"

A "Yeah."

B "So costing is a massive, yeah, you know, we've reduced our budget massively but we're always trying to …"

A "Do more."

B "Yeah, save more money essentially. Time is another one. A lot of the reasons why the allotment programme sort of, erm, faltered is through time issues. It takes up too much time, you know, getting the children over there, getting them ready in their wellies and all that kind of stuff, getting the equipment ready, it's part of that but it takes time to do that, at the end of the day."

A "Yeah. So do you think there's any ways you could eliminate, like, if you were like had time or you could kind of control or eliminate, do you think there's any ways you could eliminate these or do you think it's just a genuine 'we need more money and we need more time'?"

B "[Laughing] Isn't that always the case? Erm, I can, the only other thing that I'm trying to do this year is sort of change some teachers' attitudes towards science as well. I think cos some teachers feel that it's one of those, it's not as important a topic as your English, your maths, whereas there's huge potential in science to absolutely improve the English and the maths, you know what I mean. Erm, so there's definitely that, it's almost like limited as well some of the attitudes of the teachers."

A "Obviously I'm biased because I think science is the best."

B "Exactly, it's the same for me isn't it. So, but there are some teachers who think 'no I haven't got time to do that'."

A	"And why do you think, do you think it's because they think other things are more important or there's something going on for them in terms of science or maybe …?"
B	"Or maybe their knowledge, yeah cos that's one thing, we do, you know, a science knowledge audit or sometimes they blame the lack of equipment and then I go and find the equipment and it's there. So, yeah it's difficult to sort of pinpoint, you know, you're relying on people's honesty but from what, from my perspective it's, they've just got an attitude in terms of English and maths have to be more important."
A	"And do you think, and this is the huge debate and this is why I really wanted it, I felt really strongly about primary school cos I think, especially since they got rid of the science SATs, I think that, do you think that's …?"
B	"It lowers the importance of it, yeah and, erm, there's, I don't know if you've seen, recently, literally like last month, there was a report from Ofsted about, erm, working scientifically and there's been, there's going to be, you can see there's going to be a big push now on science. I mean the Foundation subjects anyway are getting more scrutinised, they need to be now the same level of assessment as your English and maths, which is huge and I think we're going to push that in the science, working scientifically. But then, working scientifically, I feel, is a bit less tangible in terms of how do you, you know, sort of standardise that, you know what I mean?"
A	"Yeah cos it's more like, it's a bit more vague sometimes and you're like 'well we did something and we worked scientifically…' "
B	"Yeah and you don't necessarily assess it in the same way that you assess the knowledge, you know it or you don't but working scientifically is how you can apply it and you've got to have them opportunities in other areas. So, I think that's a big issue."
A	"We'll see. At least it's being addressed, I guess, or being more like highlighted on it because I feel like, obviously from my experience of secondary, you get some kids that have done loads of science at primary and some nothing and it's just, just …"
B	"Yeah, a massive difference."
A	"Yeah and especially with the curriculum, a couple of years ago when evolution and everything came into the curriculum, it was like, it's getting

harder in science yet less is being taught. So, erm, so obviously this question here is if you were leading each outreach programme, and I guess you do lead the outreach programme, yeah, so maybe it can be an opportunity, well I suppose, the science workshops I suppose you can talk a bit more about that but basically, you know, what do you think works well, what do you want to keep the same or if, what would you do differently? So maybe it's easier to start with the science workshop that kind of is something that you don't design. So what do you think works really well with that?"

B "Well the practical element, the fact that the children are getting hands on, erm, because from that you do get a lot of discussion, a lot of, you know, erm, their vocab just comes out naturally almost from the children. Erm, but in terms of what I'd improve it would be sort of the, and this is like real sort of teacher thing, the outcomes in terms of being able to have proof of the outcomes, evidence of the outcomes, you know, because sometimes the outcomes can just be a picture or two and then that's not really a tangible sort of …"

A "You want a …"

B "A piece of evidence, you know, they've either written something about it, erm, …"

A "So how about, maybe, obviously you've got the allotment and you've got your club and that's something you design, like, is there anything you're going to change for this year that you think maybe …"

B "Erm, well in terms of the allotment we're trying to change that around so that all year groups get involved in that and I will put on that, sort of the science, 'I can' statement, you know, the mapping of the objectives, I've started putting into each year group, you know, literally the 'I can' statement can be 'I can go to the allotment and study a local habitat', so it's there in black and white, they have to, you know, they follow this mapping of the objectives, so it's there in black and white 'go to the allotment' and then they have to go as part of their science lesson and then I'd expect to see, like, evidence of that."

A "Yeah and anything you'd change about the science clubs that you're doing from last year or has it worked well?"

B "It's worked, yeah it works well the science club. Erm, and I think the response to it has been really good. Erm, yeah, no, I'd keep that the same. I'm always looking for new experiments and things to try, I don't want to just

	keep doing the same thing over and over again, for my own sake if you know what I mean."
A	"Is it, you do slime, volcanoes …?"
B	"Yeah so like eruptions, we do sort of experiments where, erm, forces, erm, using like balloons …"
A	"Have you got the equipment at school or is it …?"
B	"I buy a lot of it in which is where the cost comes in. So, but then like some of the costs are things like the cost of the bicarb and vinegar, you know, that kind of stuff. I would like, I would like to sort of get in touch with some secondary schools and I've tried this in the past and sort of, like, borrow some, you know, secondary equipment in terms of, erm, chemistry especially, you know but I'm not really sure whether I'd need, like, special licenses to handle it or even, obviously I'd need training or something, so, but that's something I'm looking at at the minute because the science club I did for the first time last year and again this year."
A	"Fabulous. Well, I've just come to the last bit so, kind of, when, what I kind of see is, like, I want to find out what's going on and basically my next kind of steps are coming in and maybe seeing some of these happen and I mean, if you'd rather not but it's just, would you be happy to be involved in maybe the next stages of …?"
B	"You want to come in and see my science club?"
A	"Yeah."
B	"By all means."
A	"Yeah. It would be, obviously, I'm working that out so you can say no but at this point are you happy if I contact you again?"
B	"Yeah."
A	"Fantastic."

Interview form a secondary school teacher

A=Interviewer

B=Interviewee

B “Sorry it’s took so long to get hold of me.”

A “Oh no, no, it’s my fault, like, it just wasn’t playing games. Erm, so thank you for agreeing to do this anyway.”

B “That’s alright.”

A “Erm, I don’t know, did you have chance, obviously it’s today, did you have chance to have a look at what the study is about or …?”

B “Yeah, yeah, I’ve e-mailed you the form back actually just in the last 5-10 minutes.”

A “Oh thank you, thanks. Erm, well basically I used to be a teacher until about a year and a half ago, erm, and then I got the opportunity to do a PhD so I’m doing research into what teachers think about outreach and basically what I want to do is collect all the views of teachers and rather than people, I guess, thinking ‘oh this is what we think teachers want’ I want to kind of propose ‘well actually I’ve talked to teachers and this is actually what they want’. So to kind of do that, what this interview is today is just asking you about your experiences that you’ve had at your school and then, so the first part of it is really just, erm, just asking you what’s going on and then the second part is what do you think about them. Does that sound okay?”

B “Yep.”

A “Right, so, if you’ve got a few things going on I’ll kind of go through the questions. Erm, so have you got any science based outreach that currently operates at your school? So this can be anything from trips to clubs, guest speakers etc.”

B “Yeah. It’s a bit hit and miss round here cos we live in the Lake District so we’re totally cut off. So it’s never just a case of nipping here or nipping there but we do do, erm, it kind of is hit and miss throughout the year. [Unclear] some kind of science convention a few weeks ago and Brian Cox was there.”

A “Ooh what was that called?”

B	"Erm, I'm sat in front of the computer while I'm talking to you so I'll Google it while I'm on the phone to you. Erm, they do, we get the Planetarium comes in once a year and we do that but to be honest, it's quite few and far between because we're so cut off."
A	"Yeah."
B	"Even to get to, like, Manchester is like two hours on a coach. So it's quite rare we get out or people come to us cos it's such a long journey. It was called the Westbury Science Festival we went to where Brian Cox was. That was about an hour and a half journey to go up there and see him. Erm, what else do we do? We've got a big ship yard in the town where they build a lot of submarines so we've got quite a lot of links with that kind of trying to get our kids talking [interruption in room]. Sorry. So, we have a lot of links with, erm, you'll have heard of BAE Systems, we've got a big ship yard in town so we work with our Key Stage 4 kids a lot and they do a lot of stuff getting ready for apprenticeships in there, that's what most of our boys go into. But other than that not really."
A	"Well, I mean, obviously you've said location and we'll kind of talk a little bit about why some of these things are a bit more difficult but if we just focus maybe on a couple of them I'll just go through a few more questions if that's okay?"
B	"Yeah."
A	"Thanks. So the science convention, I mean, erm, who was it who was there? So Brian Cox was there, who else was there or …?"
B	"Yeah there was quite a few guest speakers, to be honest, it was our Head of Department that ended up going in the end because we didn't get back until about 11.00 at night so everyone was kind of barred out of it. There were quite a few guest speakers throughout the day, sorry, I should have locked the door [interruption]. Sorry."
A	"It's alright, honestly, don't apologise."
B	"Erm, who else was there …? Just thinking now, I think there were people from Robot Wars were there and stuff like that."
A	"So, erm, so is that the first time …"

B	"Yeah it was to do with getting parents involved as well. Everyone's parents were invited to go. Because there's no, the closest uni to us is an hour and a half away as well, so a lot of the times the kids don't even think of taking science up. We do a lot of stuff with getting parents in and getting them to think a bit further than getting an apprenticeship in the yard."
A	"Yeah. But I mean do you have, is it …?"
B	"It's run by the University of Manchester according to this so the Nuclear Institute of Manchester University were there, a variety of professors giving speeches to show how you can get qualifications in science and engineering."
A	"Yeah so it was like an inspirational kind of event, would you say?"
B	"Yeah."
A	"Yeah. And did it …?"
B	"It was all careers."
A	"Yeah. Very much career focussed. Who actually attended the event?"
B	"So we had about 20 KS4 students go on that."
A	"Yeah and was that voluntary?"
B	"Boys and girls."
A	"Was that voluntary or were they selected?"
B	"We selected them. We selected quite high app students."
A	"Yeah and did they have to, did they have to pay for that or was that a cost covered by the school?"
B	"No the school funded it, in fact I think it was free, we just funded the mini bus but I don't think we paid for the tickets anyway."
A	"Yeah. And do you think it was a differentiated programme, like an event?"
B	"Erm, not, we only took kids from our triple group so like our high achievers cos really it was about encouraging people going off to university so we kind

of just did aim it at the top end, to be honest. There wasn't, that's the case for 99% of the things we do, unfortunately."

A "Do, erm, does it link, did it link to any of the curriculum at the minute that you're following?"

B "Yeah the physics curriculum, it linked straight into, that's what Brian Cox's speech was all about."

A "Oh right, great. And did you, did the kids get …"

B "It was directly about what you're doing now and how that can lead on to other things."

A "Yeah and so he kind of picked at what they were learning in school, that's really good. Did they get to see any, like, specialist equipment that wasn't available at school?"

B "There wasn't anything they could use. There was bits that the university had brought through but I wouldn't like to tell you what they were but there was certainly nothing, like, hands on. It was like talks …"

A "And demos."

B "Hhmmm."

A "Yeah. So just going on to the, I think the link with the ship yard because obviously that's another end of the opportunities and so how often do kids visit this, erm, company or this area?"

B "They don't really go there because it's a security issue because they build nuclear subs there so we get speakers into school."

A "Oh okay."

B "We've had members of staff go there on training days but as a general rule it's people from the yard that come in and they do all kinds of stuff. They come in and just give general careers talks or some kind of, there's a competition that runs around here called 'Top of the Form' where every year, it's like a science and engineering quiz, it's a bit like, erm, what you see on telly but there's always like practical, erm, science and tasks so they might have to build a rocket or last year it was a bit like jenga but it was all, they had to pick these big bits up and see how they all fit together. So they're very, like, practical things they have to figure out and that's quite a good one that they do. But again, that's mostly, we always enter our kids who are triple into that. It's very competitive and all the local schools get involved in that so it's again more aimed at any of the kids that are wanting to go on to do or are likely to go on to university."

A "Yeah. So is it a bit hit and miss but quite regular throughout the year, would you say, a couple of times a year?"

B "Yeah. There's no, like, set programme, it seems to depend on, they have like, erm, champions if you will, I don't think that's what they call them but so they have some people that come in maybe, they go round all the local schools and they're allowed off their normal job for maybe ten days a year to go and do some outreach work with local schools and that tends to be easy. They might take them through the aptitude tests they would have to do or they might talk to them about the different, like, specialist jobs that they do. Again, it's not very practical because it's difficult to get kids into the ship yard."

A "Yeah. And so how many kids do you think roughly get to experience this, like, in a year?"

B "A lot. Through the BAE thing, at some point, everyone that's in Year 11 every year will get to see them in one way or another. So you're talking maybe 140 kids a year will experience it in some way, some more than others because if we've got a limited resource we tend to prioritise the kids who have said that's what they want to do. They want to have an apprenticeship in there so we give, so that's not necessarily based on aptitude that, it's who's wanting to get in and who's not although they are quite, sorry, go on."

A "Sorry, no. I was going to ask, like, so obviously some of the programmes, some of the things they do everyone's invited and then some of the stuff they select the pupils, is that what you're …?"

B "Yeah, yeah."

A "And do you have to contribute anything financially for them coming in?"

B "No."

A "None, that's great. And does it link to the curriculum at all do you think?"

B	"Not really. It ties in with all the, like, careers and guidance stuff but not the science curriculum."
A	"Yeah. Do you think it's differentiated?"
B	"Possibly more the technology curriculum but still that's a bit of a tenuous link."
A	"Erm, and do the kids get to experience any kind of specialist equipment with this one?"
B	"Erm, it's a shame cos up until this year we've always gone on work experience so if we're thinking back my year group are going to be the first year that don't do it because they've started charging quite a lot but up until last year we used to have about maybe 15 actually go into the shipyard for a fortnight and they would have done a lot of the more practical stuff but that's all gone now, as of this year. So that's, some of it, it depends if you're thinking currently or what we've done in the past."
A	"Yeah. I can't believe they're starting to charge for work experience now."
B	"It's the company, the local college holds the database with all the risk assessments and all the companies and they say they're not prepared to provide that part of the service for free any more so we can't risk assess every single place in the town so we've had to knock it on the head."
A	"Yeah. That's a shame. So that's kind of, erm, kind of what I've, just the questions about what obviously happens, erm, so now, like and it can be quite general, based on anything that you've experienced, what do you think the benefits are of these types of programmes?"
B	"Well we had a meeting about this a couple of weeks ago because our Year 11s are quite lacklustre, let's put it that way, and we all feel that if there was more that could get them excited about science, they would want to do better in science. So I think the benefit is that they actually enjoy, cos the curriculum's quite dry and they sometimes don't, like, they're not that bothered about going into science because it hasn't been that exciting this far other than putting a bit of magnesium in a Bunsen burner every now and again. There isn't, you know, this great range of dead exciting practicals we can do and it is location wise as well as we're pretty cut off and we can't just nip and see [unclear], there's not this exhibition on here so, erm, it's quite difficult to get them really excited about it so the knock on effect is they don't

go on to do it at higher education whereas if we had more of that and they could see that more and do that more now, then there would be more want to go on to do it. I've just been teaching about graphene this week with Year 10 and they've just, just got no, I was saying how exciting it is and they were doing nano science and saying 'we can do this with it now …' and they just, it's totally out of their realm, they want to go in the shipyard 'we're just gonna go in the shipyard like me'dad' and that's it, there's no, like, very few and far between are the kids who have got their heart set on doing any kind of science career."

A "So even, obviously, even just thinking of these pupils that attended the, erm, the convention, like, what do you think the positive impact on them specifically is?"

B "For them, they're the kids who come away with, like, the more positive of 'oh wow, we could do that, I want that' and it's, that would spur them on to at least explore the possibility of a career in science when they leave school and want to push on in their GCSEs, rather than just, cos it just opens their eyes a little bit more doesn't it, to kind of, you know, the potentials of it, the different possibilities cos I think, without all that outreach stuff, you don't see it now cos it's all just content heavy and it's quite dry and so it just gives them that flavour for, you know, that inquisitiveness and makes them want to ask more questions rather than just being spoon fed and more content."

A "And exam machines."

B "And we all strongly felt, cos when we had the, the question that was put to us was 'how are we going to improve these outcomes in Year 11?' cos the staff are working their arses off, how are we going to get the Year 11s and we all said 'we need more outreach stuff', we need them to be going 'we love science, we could be a scientist and we loved meeting that person, we loved it when we saw that' and that's what we don't get at the minute because we don't really do much outreach."

A "Yeah, yeah. Well, I mean, obviously, kind of the other end of the scale of that is how do you, do you think there's any negative aspects that could affect pupils that go on these outreach activities or experience of the outreach? Do you think there's anything negative?"

B "The only issue we stumble against in school and it's not really a negative to do with the science but we come up with, because all the GCSEs are so intense now, staff are really, really reluctant to let them go out for a day and just focus on science because obviously normally they'd have two hours of English that day and an hour of maths so it does impact, like, it impacts on other areas of school. I think it only enhances the science, I don't think there's any drawbacks for science at all, no, but if you spoke to other staff, we were constantly organising a trip here and a trip there, especially because it has to be a full day because of where we are, we can't just go for an hour, it really does impact on, like, all the other GCSEs. But I would say that's probably the only downside for the kids."

A "And I think the next question I've got here, you've definitely touched on in a few of your answers but I'll ask it because you might have something else to add and it's can you describe what could limit a teacher's involvement in these particular outreach programmes?"

B "Right. So, for us, it's about location which I've said about a hundred times but we are, I mean, I know if you, I picked up from your first e-mail that you were maybe thinking about coming through to do this, like, you'd have seriously regretted it [laughing]. It's like, you couldn't be any more arse end of the universe where I am. Money, obviously schools are really tight on money. Money, it's time and for us, it's where we are which is quite a unique problem. Our nearest city is Manchester and that's nearly two hours. There's Preston and UCLAN but I mean, the uni's are quite good at getting you in but not necessarily for science stuff. They'll do like a tour for the whole day so you might do an hour of science while you're there but you might not. Erm, so, yeah, no …"

A "And obviously this is not naming any names or anything but I mean, other than the kind of general reasons, do you think there's any reasons that particular staff might be more reluctant even within the department?"

B "Erm, well it all really ties into what I've just said, so, like, for me, I've got a one year old so to go on a day trip ultimately we're going to be getting back really late at night because we've had to travel so far. It all really ties into the …"

A "You having a life as well."

B "When you're going from our school, it does kind of put pressure on, you know, you have to leave from work and all that but actually I don't think that would put anyone off because I think we all recognise the benefits, it's just a logistical nightmare."

A	"Yeah. And just the last question, erm, the last thing about this is, so I'm kind of going to spin it round on yourself, if you like then had the power or were leading any of these sessions that you've been on or were in charge of the outreach, what would you like, what's kind of working well, what would you keep the same or what would you like to do differently maybe?"
B	"If I was running an outreach session?"
A	"Yeah or you could use …"
B	"Is that what you mean?"
A	"So even if you think about, for example, the science convention you went to, what did you like about it, what would you maybe change to make it better, just kind of putting it as a what went well type?"
B	"Well for me it's making sure they get chance to do some practical while they're there. Erm, I took some kids to the uni last year and they were using their, they were making robots and it was all they talked about all the way home. So that kind of thing where they can actually get stuck in. For kids, like, there's a really fine line, like there's no point getting a really intelligent scientist who can't relate to them at all, so I think what's really important is who you've actually got speaking there. They can either capture their imagination … We went to one a few years ago, an astronomer came, I can't remember his name, erm, and we took the whole of Year 11 and even I sat there kind of staring, I followed him for about five minutes and then he just, he was probably the most intelligent man I've ever been in a room with but I couldn't follow him and it just wasn't pitched right and I think that's really important because, you know, to get a really, really good scientist isn't always the only ingredient you need is it, you need someone who can put it across in the right way as well."
A	"Yeah. And what do you think you would, what do you think, oh, forget about it, you've already answered it. I was going to ask the same question again. Erm, no, we had a, we were doing some outreach and we got some speakers in from a company and we were just all sat there with our head in our hands because it was so dry and I was just like, the kids, you know, when you're an adult and I'm not engaging with this either. So, it's just one of them."
B	"You are expecting them to behave."

A	"I know and you're trying to, like, but you're like falling asleep yourself. So basically that's kind of the end of the questions. Erm, the last thing I just want to ask and honestly it's fine if you change your mind at any point but are you happy if I contact you again maybe?"
B	"Yeah go for it, yeah. Whenever."
A	"And I know you're obviously, you say you're out in the skids really but I suppose you have presented a unique thing that I haven't got from anyone else which is location. Usually money and time is definitely there but location is something probably I've not considered before as well so that would be an interesting thing just to catch up on."
B	"Well you're more than welcome to come through and experience just how remote things are."

Interview form a sixth form college teacher

A=Interviewer
B=Interviewee

A	"So I just really want to find out if there's any kind of outreach activities that happen here at the college, so that's anything above and beyond that you would do than just a regular lesson?"
B	"So by outreach do you mean going to …?"
A	"It can be going somewhere or someone coming here, so anything that kind of …"
B	"So, erm, I am part of the Speakers for Schools, have you heard of them?"
A	"Is that where you go …?"
B	"No, no. So this is where I have registered the college for Speakers for Schools. It's a charity and they send us, once a year, somebody to come and do, have a talk for half an hour with the students. We've had a neurobiologist, an engineer and last year we had a gentleman who was Head of Public Health. So it's a whole range of different, normally science based, or Stem subject based and it's a great opportunity for the students to first of all get a kind of lecture, almost like a university lecture, but also to hear about

where they've come from and see that you don't always have to have been born with a silver spoon in your mouth to be able to reach to these high heights."

A "Yeah."

B "So it's been very good."

A "So does that happen once, kind of once a year, yeah."

B "Yeah. And we visit companies, erm, it's quite hard to, it used to be very, very easy, I think companies used to get money from the Government for doing community education things and then that stopped so then it became a lot harder for them. Like we used to go to Pentagon Chemicals and they'd shut the plant down for the day and we'd take our students so they'd get to see the research and development, they'd get to see the big plant, the health and safety, but it's become very difficult to try and arrange those type of trips now."

A "Is there any businesses that you still manage to get into?"

B "I haven't managed to get into any last year. I contacted, they keep changing their name, they used to be called Eden Bio Design over in Speke, I can't remember."

A "Jaguar used to do quite a big programme."

B "Jaguar do, yeah, the engineers definitely go to Jaguar and JCB, they go to JCB as well. So getting into the labs is quite difficult, particularly if you've got more than 20 students. We've tried United Utilities and they only want to take 10 students so if you've got a group of 30 then that's not equal opportunities, you know, you've got all that kind of stuff going on."

A "So …"

B "We do try and knock down doors but it's quite hard to get into places."

A "Just going back to the one for the speakers, erm, just a little bit, who is this programme open to, which students?"

B "All schools."

A	"All schools."
B	"And colleges."
A	"And does it take place at the college?"
B	"They come to your college yeah."
A	"How, on average how many pupils do you have that have attended these speaking sessions?"
B	"So here we normally have between 30-50 but we're quite a small college. I know from the speakers themselves that when they go into schools, you're talking 200-300 people."
A	"And does this cost the college anything?"
B	"No, which is wonderful."
A	"Yeah, so I assume it doesn't cost the students?"
B	"Because it's a charity, yeah."
A	"That's good that because sometimes there is."
B	"It's wonderful. The other thing that doesn't cost anything that we do which would, it is kind of half way between the actual visits and them visiting us is the 'I'm a Scientist, Get Me Out of Here', have you heard of that?"
A	"The … is it?"
B	"It's Welcome Foundation."
A	"Yeah. I've heard of it. And …"
B	"And they also do 'I'm an Engineer, Get Me Out of Here' so basically there's 2-3 weeks and they do this over three different, erm, points of the year. So 2-3 weeks where there's a competition with a scientist, the students go on and they find out about the scientists but what I normally do is I normally book a half an hour live chat so you get a group of scientists, maybe 2-3 scientists on a particular subject and the students can do a live chat with them."

A	“And what, is that a cost or is that …?”
B	“Nope. That’s the Welcome Foundation.”
A	“And they can do it here then can’t they because it’s remote.”
B	“All I need to do is book a computer room.”
A	“That is, I mean that is outreach because obviously they’ve set up this programme that can be done. You don’t have to do that but, erm, …”
B	“I don’t have to do this because of school either. I just found it.”
A	“That’s it. Do the, is the programme the ‘Get Me Out of Here’ scientists, is that differentiated would you say?”
B	“It’s differentiated in that there’s different tasks. The students can ask questions actually when we’re doing the one to one or they can do it in their own time. They can do it at home. We have, they give us lesson plans that teaches a little bit about, again this is where the scientists come from, what’s their background, what they were like at school. Again, inspiring them to go, you don’t have to be an A* grade student in order to get on and do these things.”
A	“So one of my questions is does it highlight any future career opportunities and pretty much every one, yeah.”
B	“They do.”
A	“And do you ever get chance to use any equipment with maybe the speakers that isn’t readily available here?”
B	“I’ve not done that here but I know, erm, over in Warrington my colleague has got in, I think it’s called, it’s called ‘Spectoscopy for the Day’ or something like that.”
A	“Is it ‘Spectroscopy in a Suit’?”
B	“That’s it, yes.”
A	“That’s an RSC one as well.”

B	"So 'Spectroscopy in a Suitcase' because they don't have the specs and stuff that we've got here so they've had them come in and the students loved it again, interacting with just people from outside."
A	"So, I mean is there anything else that you …?"
B	"Yep, Manchester University, they run, is it training days or something like that, again it's free."
A	"Is this for students or teachers?"
B	"For students. So we've been to the PCR day and the students get to go in and use PCR and DNA extraction, electrothesis, we've got some of that kit here but we can't do PCR, it's too complicated. So they get to go in and do that at Manchester University as part of the Museum and we've also done a stem cell day where they cultured some stem cells and then got to speak to PhD students about their work on stem cells."
A	"That's great. Do you have to pay, do they have to pay anything for this?"
B	"Er, I think we paid for the stem cell but it was quite cheap. It was something like £100 for the whole group to go so it worked out about, I mean I'm talking three years ago, I think it worked out something like £5 a student or something like that."
A	"What about transport, is that something you provide?"
B	"We've got a mini-bus and myself and the technician are able to drive the mini-bus and that worked when we had smaller groups but now we're a combined college it has been a major problem trying, cos college won't fund it and the students won't pay for it unless you ask them at the start of the year which we didn't do. So actually getting transport to places is the biggest thing."
A	"Yeah. So just moving on maybe I guess to the more generic questions. What do you think the benefits are of any of the programmes that you've described? What do you think the benefits are?"
B	"The main one is interacting with new people for the students. It builds their confidence in terms of if they were going to have an interview, they may be a bit more confident about talking to strangers because in FE that is the biggest

thing, the confidence. Picking up a phone, talking to a stranger is such a big barrier for them."

A "Because if you think about it now, even I, if it's an unknown I'm like 'I'm not speaking to that person'. It's the culture people are growing up in."

B " So but they need to get over that because I'm always saying to my students not to be, not to be anti-private schools but I keep saying to them the difference between college and a private school is they are taught how to deal with the world. They are taught how to hold themselves, how to speak, how to get over barriers whereas you aren't taught that and therefore you automatically go into your shell which means if you go for an interview, that's you, you're not going to get it."

A "So …"

B "So the biggest thing is that it is giving them confidence but also opening their eyes to different career paths as well."

A "Yeah and so I suppose the next question is kind of linked. So what do you think the positive impacts are on the students?"

B "Most of the time for mine it would be, erm, it actually sets them in the direction they want to go and study at university because they come here with an idea of wanting to study science but they're not sure what science and as they go to these outreach things it helps them narrow down and discount things that people maybe thought they would have liked and go 'actually, it's not for me'."

A "Well that's it, it's important that if someone really thinks they want to do something and they go on this day and it's like 'I hate blood' …"

B "Yeah. And I'm just thinking about another thing that we did is we went to Betws-yCoed on a field study course for a day."

A "Betsy what?"

B "Betws-y-Coed, it's in Wales, don't ask me to spell it but it is the, now what it is, FSC, Field Studies Council, we've got to pay for that but they do courses and they do one day courses and they do one week courses and I went there with a group of students two years ago and from that one of them jumped straight from science into geology and is now studying geology at university cos she just loved being outdoors so much."

A "And I suppose this is something that, I mean, obviously at an FE level, you know, a lot of at primary when you're talking about careers and even secondary, is more hypothetical whereas obviously these students are at the pinnacle."

B "Yeah they have because they've chosen science and okay they might not stay in science but certainly it gives them problem solving skills and all the other things. I keep saying it's like learning a language. It shows a level of intelligence if you can do well in science."

A "So this is kind of one I'm thinking maybe the other way, do you think there's any negative impacts that might, like these experiences could have on a student or do you think there's any negatives students might experience on these days?"

B "I would say there's ambivalence maybe in some of the students where they go and they just go 'I don't know why we went there' because they've not, just because of the type of person they are. They're not really bought into the experience. I wouldn't say there's anything negative out of it."

A "So I suppose, thinking of the type of individual, cos obviously you are going to take time out of the day and take them and especially if they have chosen science, there's a level of expectation they are going to engage with it. Do you find there's many students that kind of go and just aren't interested?"

B "Yeah, yeah. They're happy to go because it's a day out of the class, erm, but they're not necessarily, so say for example we're going to Jodril Bank at Christmas, we're going to do spectroscopy with them and I know out of the 35 students that we'll take, there's probably about 15 of them will probably not be interested because biology is the bit that they're interested in."

A "Yeah."

B "But it's not a negative thing. It's just that you have to expose them to everything cos you've got to break down their pre-conceived ideas haven't you."

A	"Yeah and thinking more from, like, a teacher's perspective, what do you think could limit a teacher's, not just yourself but anyone's involvement in these kind of outreach programmes? What do you think the big limitations are?"
B	"The biggest limitation is transport and the second one is being able to fit it in to the curriculum because if we do a trip it has to be associated with the curriculum. Like we used, I know it's not the same thing but we went paintballing because it's team building if you go paintballing. We're not allowed to do that anymore because I can't say how it involves science."
A	"Yeah."
B	"So it is fitting it into the curriculum."
A	"I just realised I forgot to ask you if the programme, so, does, do these fit into the curriculum?"
B	"Yeah."
A	"You just reminded me I'd skipped that one. So, and obviously you said that the transport, it's kind of the cost element that's … yeah."
B	"It's definitely cost as well."
A	"Erm, any, so, do you think there's any ways that, you know, like obviously you said transport and the curriculum, if you had the powers that be, what kind of stuff do you think you would do to reduce these limitations?"
B	"I would set aside a budget, erm, probably have, like, local companies that would be contracted to us, so we could guarantee we'd do ten trips a year, what are you going to give us, to give us a good price as we're buying at bulk. Erm, the only limitation is getting into factories is we benefit from it but the factories don't really, like, going into companies so if there's some sort of incentive perhaps from the Government, like we used to have."
A	"Yeah. Cos it feels like you're asking and eventually, well, yeah and that's it because obviously if you're going somewhere like a university there is an incentive because they might go to that university whereas …"
B	"If you're shutting down your plant for a day that's a day's profit lost because you shut it down for some college kids to come in who might never work for you."

A “Yeah, that’s it. So maybe, I’ll definitely look because that sounds impressive really, shutting down the plant for the day.”

B “That’s what …”

A “It shows great value in what they feel … So just the last kind of question and it’s kind of based on an amalgamation of what you’ve said and these, mainly these programmes. So, thinking about the outreach activities you’ve engaged with, what do you kind of like about them and you’d keep the same or if you were, like, the project officer for each one, what do you think you would change, like looking in and thinking ‘oh I could do that, that would be better if …’?”

B “Probably having some sort of lesson before the visit and something after the visit. So sometimes when we go to places they will give us questions for students to take away but then they’re not involved so to have the companies, I know it’s a lot to ask, but for them to then maybe, I don’t know, look over what students have answered and then give the feedback rather than just say us doing it again. [Unclear] the activities that they’re involved in and not just us.”

A “Yeah. And what do you like above the, erm, what do you like about some of the stuff? What do you think works well?”

B “Erm, what I like about them is just being able to expand the students’ experience and expand the students’ ideas. Obviously the ones that are free are just absolute gold dust.”

A “Yeah, nothing’s free really these days.”

B “No, we’re just so lucky to have a couple of things that are out there that are free.”

A “And obviously we’ve talked about the benefits and the things that work, do you think the impacts of these experiences is long lasting?”

B “Definitely because, as I say, some students have chosen their next step and next step in education based on what we’ve done, based on the visits that we’ve done and I’ve even had, cos I’ve been here 11 years, I’ve even had students go to university and start a course and then not be able to get something like sea micro-biology, we went to United Utilities and we saw the

	micro-biology lab and they couldn't get it out of their head, they just kept and went 'well actually I've chosen this course but I want to go and do that' and they've changed their courses afterwards. So I think it is life long learning for them."
A	"That's great."

APPENDIX K: FOCUS GROUP SCHEDULE

FOCUS GROUP INTERVIEW SCRIPT

WELCOME

Thanks for agreeing to be part of the semi structured interview process as part of the focus group. I appreciate your willingness to participate.

INTRODUCTIONS

Researcher (moderator) and if possible (facilitator)

PURPOSE OF FOCUS GROUPS

The focus group is intended to investigate teacher's views about science outreach programmes and what your reasons are for engaging with these initiatives. It will also link to the perceived impact you feel these programmes have on more disadvantaged pupils. All experiences and views of science outreach work are valued as part of this study, as its these views that will assist in providing a 'sustainable model' of delivering these outreach programmes to ensure they are feasible and manageable by all.

Results from this research, along with relevant literature, will inform the development of further research in this area and may lead to publication, dissemination of findings and recommendations for the development of policy and practice in this area.
I need your input and want you to share your honest and open thoughts with me. I have identified various themes for discussion and I will introduce each theme briefly before asking you questions based on that theme.

GROUND RULES

1. We want you to do the talking

I would like everyone to participate. I (or the facilitator) may call on you if I haven't heard from you in a while.

2. There are no right or wrong answers

Every person's experiences and opinions are important.
Speak up whether you agree or disagree.
I want to hear a wide range of opinions and I am very interested in hearing your views.

3. Try to be focused

Time is limited so try to ensure your answers address the themes and questions raised.
It may be necessary in order to cover all the themes to move the discussion on. I will warn you if we think that we will need to move on for reasons of time management to allow for any further comments.
I will also provide participants with an opportunity to submit comments in writing in case there has been a need to curtail any discussion. Please see the contact details for this.

4. Sharing information with others

I want participants to feel comfortable sharing. As such, you should not discuss any comments attributed to anyone other than yourself outside of the focus group. By completing the consent form you agree to this principle.

5. Tape recording the group

I want to capture everything you have to say.
I will not identify anyone by name or school in the dissemination of findings or publication. You will remain anonymous.
A transcript of the Focus Group will be provided to all participants if requested.

DISCUSSION QUESTIONS/THEMES

We would like you to discuss the following questions and themes:

- ***What is science outreach? (5 mins)***
  - *What do you think it is?*
  - *Describe some of your experiences of these programmes*

- ***Science outreach in general: (5 mins)***
  - *What are the general benefits*
  - *Are there any negative aspects to these programmes?*
  - *What stops you from engaging with these activities?*

- ***Pupils and science outreach (5 mins)***
  - *Which groups of students benefit from these science outreach initiatives?*
  - *Do you think pupils want to be involved in these programmes?*
  - *What do you think the benefits are for pupils?*
  - *Do pupils remember these experiences?*

- **The initial/final model (present a visual to the group and each person has a coloured pen) (10 min in groups, 10 minutes feedback)**
  - What are your initial thoughts?
  - Do you think the model reflects the educational journey in science?
  - Would this model assist with the delivery of the curriculum?
  - How would you change it?
  - Is there anything you would add?
  - As a teacher, are there aspects that seem like they wouldn't be viable?
- **Now considering pupil premium students; (5 mins in groups 5 mins feedback)**
  - which aspects of outreach are the most important to engage this group of learners?
  - Is there anything you would add that may be specific to this group of learners?

- **Summary (5 mins)**
  - What are the key changes to the model to be made?
  - Any other points to add.

SUMMARY

After 55 minutes or once the conversations come to an end I will summarise the findings and ask if there is anything further they wish to add.
Provide participant with contact details v.k.brennan@2016.ljmu.ac.uk should they wish to add anything further at a later date.

CONCLUSION

Thank you for your time. You will be sent a copy of the transcript of the focus group if this is requested via the above email.

APPENDIX L: EXAMPLES OF FOCUS GROUP TRANSCRIPT WITH EXAMPLES OF INITIAL CODES AND MEMOS

memos.

Focus Group 1 - Interview

A Interviewer A
B Interviewees – female B
C Interviewees - male C

Perceptions & Experiences

[redacted]

A "Fantastic. So, just to begin, obviously, a really broad question, what is science outreach to any of you?

B "Er, I think it's about getting pupils engaged outside of the curriculum and trying to let them see that there's science out of context from school that, like, applies to them and that they can be interested in cos sometimes like with the curriculum it is difficult to get pupils to see what relevance science has. So if we get them out they feel really positive that they're on a trip and if they enjoy it they might, the hope is, engage a little bit more or focus and think 'oh that trip we went on was really good, it was part of science …' and maybe go from there."

C "I think careers as well, them going out and realising what they're doing in the classroom actually relates to a real life job or prospect for them afterwards."

B "Cos you quite often get 'what's the point in this?' and I think the trips put a bit of context to why they are having to learn it."

B "And I think it's a bit of a reward as well. Erm, we do it sometimes as well don't we if people have had really good behaviour for learning, we see it as a bit of an opportunity for them to, like, celebrate what they've done and say 'this is a proper trip for you cos you've done this, this and that' and again relate it to enjoyment in science really. But we were saying weren't we, it's not always about uni cos a lot of people think, doing a trip is ending up going to uni and it's not always related to that, just a potential job or a career."

C "I think that's been difficult because my old school, compared to here, at my old school everyone went to university so I think the kinds of trips we did were probably different to what we do here because the kids had different maybe aspirations or directions or different ways of getting where they want to go. So I think here, yeah, I've seen it being different, a different goal."

B "I think a lot of the trips' focus that come to us are about getting pupils to uni, I think like that's probably the aim of the provider but it's not always the outcome, do you know what I mean?"

C "Yeah."

B "I think the engagement's a massive one because sometimes, especially cos we do open evenings and stuff that's all singing and dancing science and then they get here and it's a bit like actually it's not really like that, now we've got to deliver

During open days it is a "show" and then when pupils come to school it doesn't match the expectations and they may have a negative perception of science. These outreach activities can help to eliminate these feelings and firing through and I think, like, it brings a chance to do some more of the fun side of science."

B "I think from a teacher's point of view as well it's about keeping us abreast of what's out there and them being able to inform the students erm, in the right way, you know, we're not talking all the time about when we were at uni or whatever and so I think that's good from my point of view, a teacher's point of view."

B "And the new science, cos obviously the science curriculum changes with science and it helps because it's a long time ago since we've studied at that level and it helps us keep abreast of the changes."

B "Yeah."

B "Cos even that one we went to, the Chemistry Forge, was it the one where they were talking about, you could do a degree with an apprenticeship like, I came back and was speaking about it and none of us knew about it and there was a total avenue for people, like, …"

B "To be able to share."

B "Yeah and pupils tell each other about it as well so it's good in that way."

A "So what, kind of, obviously, experiences have you had, what kind of trips or events have you engaged with?"

B "Erm, I think, again going back to a previous school, I've not been involved with many trips here but at previous schools, erm, we've had, I've done sort of, like, careers events where we've brought lots of different providers, outside providers in, erm, to speak to the children, not just from science but a wide range and, erm, and again from a teacher's point of view, it's been really informative for us because it's about us being up to date and up to speed with and being able to advise the students in the, in the right way."

C "I always think [unclear] that chemistry is more about kids in our school but I've always liked doing the stuff where we're competing with other schools. I've always found that's got an extra incentive because they're seeing kids from other schools and it gives, like, kids a boost sometimes when they go out and they see the kids from grammar schools or private schools and they're able to compete, you know, with them and they often don't think that's the case especially when they've got aspirations for uni and things and they don't think they're capable of going. When they go and they go and do competitions and realise they're just other kids and they're just the same as us, it gives our kids more of a boost that they're capable of doing those things and definitely when I've seen kids go to any level of competition, er, and they've done well, they've kind of shocked themselves a little bit and they've come back with a confidence boost."

B "Yeah [several]"

B "Yeah I've had that before."

C "And I find our kids generally do better than expected because they kind of have that extra …"

A "And do you notice anything when they come back, like, obviously when they come back?"

C "I've seen it in lessons where I've had students who are very quiet in class, they have, they like science, they're very quiet about it but they've gone away and come back and literally they can't shut up, you know, they've completely changed in the sense they've come back to the classroom and they're confident. They've always had a quiet confidence about them but haven't been able to kind of say anything because maybe they haven't had the right opportunities but then they come back and they start talking about it and yeah, I've seen kids literally change from like one to zero, in a sense, from being to quiet to maybe …"

B "I've maybe seen the opposite of that."

B "I was just about to say that."

B "That's what I'm going to talk about with [redacted] when we were in here and we had Chemistry for All and some of the girls had their photographs taken and they asked for it to be taken down because they didn't want to be …"

C "Associated, yeah. Yeah you get both ways."

B "Erm, so I've seen that."

C "We had the same with [redacted], we had a student who was amazing in class, brilliant, we took him away to a competition and we were shocked at …"

B "Unbelievable."

C "… he literally didn't, he couldn't talk to anyone. We were, he was like our star student and he went away, yeah and he went away and we were really quite surprised that …"

A "Do you think it was that, the activity or do you think it might have been something …?"

B "I, I,I think that's [redacted] because I had him yesterday as my prefect and he was brilliant. He was really helpful but when it came to interacting with the youngsters he found that difficult whereas the Year 8, the Year 8 were …"

B "I think sometimes the trips have been good in a sense as well because the students that always shine at school and always do well and outperform everybody else in the class all the time and then they've gone to something where they're competing and they've found out that actually, there are other people at their level and they're not actually amazing, they're gonna have to still work really hard to get somewhere out there. I think sometimes that sets them back initially but I think the skills they then have to learn to push forward on that, then that's …"

C "They don't get complacent then do they? It means that they're always being challenged."

B "It allows us to see that there's a gap there in those skills as well and that is something that we need to develop with those students."

C "Two big events I did in my last school, erm, which were particularly aimed, one was linked to a hospital and doing medicine in the field because we had loads of kids, EAL kids who, who were, wanted to do medicine and their idea was doctor or nothing, you know and then there became a big wave of midwife when that, when One Born Every Minute became big and that was it, it was being a nursery nurse or midwife. So I did a lot of careers links, I got [unclear 7.16] and got, like, 6-7 people from the medical field and then they did a careers fair on that. So it was looking at radiographers and looking at speech therapists and looking at the whole range. Now, for me, that made a massive difference because it was a case of it wasn't 'I want to do that', it was 'I'm going to look into that field'."

B "Yeah."

C "Erm, and it was, the same for engineering, the same for engineering, at technician level. So it was Level 2, not just being an engineer, not aeronautical, it was looking at the whole range, so I could industry in that was local, this was in Manchester and then that was looking at, you didn't have to go to university to do these sorts of engineering because again, it was either mechanic or some high idea of what an engineer is, you know, so they thought you get your hands dirty or you're a genius and actually, there's always a range where there's a lot of jobs but it was about being focussed and seeing that 'oh, they don't know what engineering is'."

C "Can I say I think we're very lucky here though because the Head really, trips are not a problem. No-one's ever knocked back from going on a trip and I think in previous schools I've worked in it was quite hard because schools often want the hard data as to the impact a trip's gonna have and often that's not the case, you can't turn round and go 'this kid's great, he's going to go up by this amount if they go on this trip' and here, it's just like they're going and that's good, it's a good opportunity for the kids in the school whereas I've had experiences before where they're not so keen on trips cos they're like 'well they should be in class learning and if they're in class learning they'll pass, they can't pass if they're not learning the stuff in the lesson' and that's been the experience I've had previously with trying to get schools more interested in trips and Heads not thinking it's important. So if the Head doesn't have it as a priority it's hard as a teacher in a school to then, you know, engage with it but here that's not an issue."

A "I mean, I suppose, following on from that and you've kind of, some of you have mentioned, some already, it's kind of like, in general, what do you think these benefits are and do you think there's any negative aspects? You've kind of highlighted a few of them but …"

B "I feel like for the more long term projects, the ones that people do weekly, it's a massive skill. I think developing communication, confidence, team, work and leadership I'd say and they're all the ones that you can't really train them for in a casual 60 minute lesson about science. You can try and get it in but the projects are planned really well by the organisers they do it really subtly so it doesn't say on the Power Point 'today we're doing team work' it's just, like the soft skills that they're focussing on throughout each week, they don't realise they're building it up and the resilience but at the end of it you can see and I'm not being, like over the top but a dramatic difference between them and, like, a few of them obviously have more of a light bulb moment than others, erm, but generally if the project's been planned well by the organisers, like the people we get in to help us do it, erm, it's a massive impact on pupils. I wouldn't say really at the end of any project I could say someone's science is better, erm, but I don't think that's why we ever send pupils on a trip really, it's to give a broad spectrum of skills, erm, I'd say anyway."

B "Erm, but no negativities, only for us a lot of the time the problem is getting people to agree to come on the trip in the first place."

C "Yeah."

B "Er, which is, we've got a lot of pupils, like, erm, don't like going out of their comfort zone at all and if three of their friends aren't going, they won't go. So we've got some trips where we know there are some specifically we want to target and for a week we're 'it's really good', we show them what's happening and we tell them and we've all ended up probably at the time saying 'look, who do you want to come with you?' and they'll name a person and then we'll say 'okay, we'll invite them too' and that's the only way. So no matter what we're trying to say, the trip's going to give you this, it's going here, blah, blah …"

C "Yeah."

A "And is that with the, is it more with the, is it across all the year groups or is it …?"

B "Not to be sexist but I'd say it's more girls who have that problem."

C "Yeah. I've had a situation where, I've had girls turn round, like the morning, the day before a trip and change their mind 'I don't want to go any more'.2

B "I've had that a lot."

C "And they've said initially, I don't know whether they've got scared, nervous, whatever and they've just changed their mind and I've had to run round to find someone else to go on the trip because we want to, you know, fill the spaces but it's, it's so common that we almost expect it now that there are going to be kids that don't want to come. When they do come …"

B "They have a great day."

C "Yeah, they do …"

A “That’s what I was going to ask, once, if you get to get them there, do they usually …?”

B “They engage really well, they enjoy it and they usually come back on the mini bus or the bus being like ‘oh that was really good’ but it’s funny cos when you ask the same person again, they’ve forgotten that they’ve really enjoyed the experience and it’s not like …”

C “The same battle again.”

B “The same battle and you’d think they’d have learned behaviour and be like ‘oh that was good, I managed it, I was successful’. Obviously they’ve got a lot of self-confidence issues and self-esteem and that’s part of the reason why we’re trying to get them on the trips but …”

C “It’s easier if it’s in school, they’re more likely to do it aren’t they.”

B “Definitely.”

B “I didn’t think in school one has a big impact though, on an outside school one, just because it’s too familiar for them and it’s not taking them out of their comfort zone as much.”

B “I think leaving the school is one of the biggest things for some of them, like, getting on that bus and going to that new place, that unfamiliar place, it’s where the problems we get and that is the …”

B “It’s like the bigger risk but once it happens …”

B “… yeah, it’s got the bigger impact.”

C “It’s not even about science. We have an end of year trip, we have like an award trip and over half the kids in school choose not to go and this is like Chester Zoo, Alton Towers or …”

B “It’s all sorts of stuff isn’t it, the cost … well things like, I went yesterday to London and one of the girls had never been on a train, not even, like, to Liverpool or anything, never been on a train. So if you think about them, it being a trip, not only is that going to be a barrier, it’s how are you getting there, what am I having for my lunch, cos a lot of them are very routined aren’t they? So you’re taking them out of their comfort zone. It’s a bit of an overload isn’t it?”

C “They ask questions you’re kind of really shocked at, like, ‘what time are we eating, where are we going to go for food?’ They’re worried about every small part of the day cos they’re so not used to doing anything other than just coming to school so some of them, some of them are confident enough to ask those questions and get over the barriers but if they’re not, you often don’t even know why they’re so nervous of coming. You can’t reassure them if you don’t actually know what their insecurities are.”

B "But again, when you get them there, like we took the kids to London didn't we, 7s and 8s. Some of them had never been away before and, you know, that experience of being in the capital city as well, obviously it was science related and that was a really, really good trip wasn't it, that we did inside the cell and, erm, and they went to the National History Museum, which I thought was brilliant as well but, erm, but they got, there was kids there that got loads out of just being in their capital city and being able to say … cos we did a trip didn't we, we did rounders in Hyde Park and that in itself was, er, and I think, cos they've got the confidence, they've done that before, they're more likely to go away and do it again."

B "Yeah."

A "So as teachers, is there anything that kind of stops you from maybe engaging with any outreach that's offered?"

B "Well we had one, we had one come through and, erm, we read the script, it was about Key Stage 4 and doing a revision programme prior to the exams and we're a bit precious of that time and, erm, but there, the wording, what did it say? Erm, the …"

C "It shows promise."

B "'It shows promise' and when we saw that we thought no, we're too precious about our kids, erm, and their results to actually …"

C "The only hard thing about what you're doing is the time it takes to plan as a teacher."

C "Chasing up letters."

C "Yeah the letters, chasing up the medical, you know, the forms, the risk assessments and all those things, they do take an extremely large amount of time and the only thing in school is there is no, the reward is you personally feeling, doing something for the kids but any staff that takes the kids outside of school is going above and beyond because of the fact that you talk about your job and your appraisal and what you get judged on as a teacher, you're not judged on taking kids on a trip, you know. So you're not judged, you're judged on our, our, on what's happening in the classroom and what's happening with the kids. I mean, you might even be taking kids on a trip who aren't even in your class and you don't get judged on some kid outside of your class and how they achieve. So I think that in your time management, you're looking at what you should focus your time on, anyone that does those things is doing everything else that their job is asking them to do and they're doing, something on top."

B "The thing is, your appraisal form does, there is a section isn't there in the appraisal form where you can show evidence of that …"

B "… [unclear 16.07] … appraisal folders …"

B "No, no it'll show it but it's not gonna, you don't get …"

C "If you weren't doing stuff, if you weren't doing stuff that were part of your everyday job you wouldn't be, you wouldn't be able to say 'oh but I've done a trip', 'oh that's okay then'. There are certain boxes you've got to tick and things you've got to be doing and if you're not …"

A "So it's the …"

C "So you are having to do your job first, the things that are deemed as your job and that's on top, yeah."

C "There are some schools that people have teaching and learning responsibilities to do this sort of thing. We don't have any of that here."

C "Some schools where a member of staff…"

B "Fletch had one when he was here didn't he?"

C "Yeah."

B "His responsibility was …"

B "I think for us as well, I think as a general brief we are able to give anything a shot, erm, but like everyone says it's the time, like our Head has been really supportive in making sure that we can go on it but again, we have, once we're back, generally we're expected to write a news article for it, erm, generally we're expected to log it onto, like on this thing called Blue Hills and that takes time. So it literally is just the time."

C "Yeah, yeah."

B "I think most schools, like whenever we go on a trip, it's always, there's loads of schools there, you know, so I think people are interested in doing it."

C "I always think with things like that, I always try and do one day a year. For me, I enjoy doing that more than I do in a classroom but I'm like I can't give it that much time but I always make sure I do one day a year I really enjoy. And I do a trip to go down, I'll give up a weekend to go down, you know and I've got a wife and kids at home but I do it cos I really enjoy it and I know how much the kids get from it but as I don't get paid any more money to go down on the weekend, some schools, especially when we're competing in a national competition, the private schools have staff who get paid to work on weekends."

B "Oh my …"

C "Yeah and they're in their contracts that they have to work so many weekends a year as part of enrichment so to try and compete at that level with schools who have got staff, having to give up the time is difficult."

B "If we could all commit to one a year …"

C “Yeah, yeah.”

B “…that would be like one a month we’d be going out so that wouldn’t be a massive thing would it.”

B “We do everybody’s at the minute so we don’t have to [laughing].”

A “So, just, erm, just before we move on to the activity, like, this is now, obviously we’ve talked about the general benefits but thinking about groups of students, like, which groups of students do you think these activities maybe have the most impact on or least impact on?”

B “It depends what it is I think.”

B “Yeah, I wouldn’t say on their ability, I’d say on their general persona, like, if you’ve got an enthusiastic pupil and you take them away, they’ll embrace it all and engage with you fully. You might have the brightest pupil who’s gifted and talented but if they’re not enthused by what your offering they won’t really benefit from it. We have a lot of focus on our pupil premium pupils. We’ve got ring fenced money and we can put bids in to get the pupils on the trip for free and we often go down that route in our department, erm, because obviously we’re trying to engage them further and trying to get them to have the exact same opportunities that they might not have, erm, by being from maybe a slightly different background but I wouldn’t really say broad spectrum, you could say G&T benefit most or pupil premium.”

B “It’s more about the individuals.”

C “Yeah, yeah.”

B “And what that specific trip or project is about. That’s just me.”

C “I definitely think the pupil premium kids. I think knowing that they don’t necessarily get as many opportunities and that’s why we often find it hard getting them on the trips because they’re the ones that are most scared and nervous .”

B “Because they’ve not done it before.”

C “And when they do kind of go I can imagine, like, long term wise, looking beyond that year, them getting out and seeing a university or doing anything outside would give them an aspiration they may not have had, you know, from the home point of view whereas if someone’s parents had gone to university it’s significantly easier, I think, to want to go to those things so to actually have that enrichment yourself by your, there are kids in this school who’s parents have taken them to museums and there’s kids who have never been to a museum before and that will link significantly into the pupil premium.”

B “And sometimes when we’ve invited them on a trip, they don’t come on the trip and they have a day off and I think their mindset is ‘well I’d have been on a trip so I’ll just have the day off’. I don’t think in some of their heads they can see the benefit of going to those experiences. It's a bit like 'well I just won't go into school, I never was allowed to be off with trips', you know what I mean."

A "So, do you think pupils remember the activities, the trips, the outreach?"

C "Definitely, yeah."

B "I think they're always good for relationships as well, like, especially the projects that you're doing at the moment, when it's long term and things like that, the benefits later on when they get into Year 10 and Year 11 and stuff, relationship wise that you've built up …"

C "With staff and with each other."

B "… with each other, yeah and with peers and with staff."

B "Because you can just be a lot more relaxed on a trip because you know the people you can trust and rely on and you can have a conversation with them about what they're getting up to in their life, on the bus or half way round the trip."

B "And it affords you that time to have those nice conversations."

C "You also find out how creative they are don't you, like Fox with his media stuff and when he's doing a science project and at the same time he's doing his media for it and how good he is at using the camera and, and making You Tube videos and things that he does. So you see other skills and you're like 'wow, this kid's pretty talented'."

C "And we're such a big school that if you didn't go on these trips with the pupils, there's a lot of pupils you'd never get to meet, you'd never know anything about them so it's really good for building up relationships with the pupils before you might teach them later on in the school."

B "Yeah."

B "And more recently I've noticed pupils coming up to us and saying, like, 'oh have you got a trip, can I come?' and that doesn't, like, a lot of the time we struggle but more recently they've been coming."

B "And they'd have been the kids that initially would have felt, like …"

B "Yeah, a few times and then one of them might be interested and they'll bring their friend and say, like, you know, they do seem genuine, like, interested in going on trips rather than being, oh just have a day off. I don't think many of ours see it as a day off."

C "I think it raises the profile of science as well across the school, you know, it is competitive in our school, like, in school, competition."

C "I'm a Year 10 form teacher and in our recent Pupil Voice, the pupils in the form said that other departments should organise as much as science does."

B "Oh that's good."

C "… always doing the trips."

Model

A "So I'm gonna move on, just so we've got enough time. Erm, obviously what I've kind of come up with is, erm, when I say model for outreach, it's basically, it's taken into consideration, I'll basically pass it round so you can see it. It's got, erm, bits of paper in case you need to write more but imagine that in the middle. If you work in twos maybe."

B "Yeah."

A "Erm, and here. So the model itself, you don't have to open it up. I think I was a bit prepared, erm, but this model obviously it's kind of, oh I've missed the ages off that, oh no I haven't. So it's kind of a cascade model, erm, and this is what I feel from talking so far, interviews and questionnaires and reading literature, kind of what the key elements of outreach should be at these specific levels. So basically for the next 5 minutes these are kind of the prompts and thoughts. So if you want to annotate it with your coloured pens, erm, and just have a little thought and then after five minutes, if we just kind of have a little discussion about what you think and honestly, I'm not precious about it, this is just the first draft. So I really, really want your kind of ideas or kind of …"

Instructions

A "If you've got any questions or anything you don't understand, please let me know and I'll try and explain."

C "I disagree with the subject knowledge. We don't tend to take pupils out so they can learn more subject knowledge."

A "Sorry, this is the, oh, that's for the teachers."

B "Oh yeah, sorry. So this is about helping teachers."

A "So down the left hand side, that's what the programme should do for the teachers and then down the right hand side maybe including the parents as well and then the middle bit is for what the activity is for the kids."

C "I'd say these two would be the most …"

B "Which ones Ian?"

– most important aspect → Role models need to be relatable and show they understand the groups of students!

C "The role models I think is, from a lot of the trips that I've been on that you've organised [redacted], erm, it's often looking at role models such as the one where we watched the hidden figures film and those ~~female speakers~~ talking about what they do because quite often the pupils don't see that the science they're doing in the classroom will lead to anything but to see somebody who's talking about things that they're learning about at the moment, in a job, …"

– give learning purpose

real life examples

B "You're actually saying that and one of the trips I went on that I didn't think was going to be all that much, and I don't mean that in a nasty way, but not sure what

low teacher expectations

Teachers are such important stakeholders in these experiences and we need to ensure they are considered too.

we'll get out of this, the pupils on the mini-bus on the way home were buzzing. It was that 'women in science' one about a year and a half ago and the lady was the, erm, Shadow Digital Technology, erm, …"

B "Secretary?"

B "Someone, yeah. She was someone really important but when we sat down it was like the room was just full of adults but as soon as they seen our school come in it was a radio presenter did an interview with this lady and he completely adapted it. It's lovely to see some young people in and he completely changed the whole interview and, I'll have to find out her name because she was incredible. She was so inspiring, she just talked about, like, women in science and directed the whole, really, seminar to our pupils and literally, when the girls left they were like 'girl power' but they really had a huge amount and that was all about role models and I think the kids see, because the woman talked a lot about her history and her past and how she was brought up and they could connect with that really well because I think, like you said before, you think they've all come from middle, upper class families and they've got these professor jobs but this lady, like, went through her whole life story and they really connected with them and we could do this as well."

B "What year group did you take, considering this is 10-12 year olds?"

A "So I've, just to explain it as well, it basically is that, obviously so you can look through the prompts and maybe annotate, erm, obviously the bottom bit, up to 9 year olds, so basically when you get to post-16 you should never not have, it's like it builds on it, rather than, so even at 16 you mention these next steps but you still are going to have hands on activities and so the idea is it kind of does everything, it never stops and then that and then that …"

C "… I've done a big circle kind of thing."

A "Please write this down cos this is obviously what I've come up with and I'm … You can write on this if you want."

[Talking over one another]

A "Draw what you think, yeah, that would be great."

C "… and then that's your real focus, that's year, that's post-16 which still encompasses everything, that's your science education isn't it?"

C "Yeah it is, yeah."

C "So you still include all of that as opposed to it being, like, a step …"

C "Yeah I think it would be better because immediately when you said it's not hierarchical …"

A "No, no, I think it's, I mean, like, obviously I presented this as a draft. This is, the next stage is being with you guys and getting these ideas."

C “I know you said here about working scientifically and enhancing practical skills.”

A “Yeah.”

C “Cos we’ve kind of gone from, like, 10-12 and I’m, just, like, if you were doing, cos to us working scientifically is quite, yeah, …”

A “I think the, because it’s 10-12 so it’s then transition from Year 6, like the Year 5-6 to Year 7-8 and just because of the different experiences they might have had, I’ve called it working scientifically and then I suppose the next bit is enhancing practical skills was more to do with the required practicals and being very, just, I don’t know, if you’ve got a better wording for it that would be great.”

C “No it’s just we use the term ‘working scientifically’ all the way through so, yeah, yeah.”

A “So maybe, maybe think about that being not working cos I knew it used to be part of the curriculum wasn’t it?”

C “Yeah we use the, yeah, working scientifically is the name for our, for the practical skills.”

A “So is there anything else?”

C “I would say, I would say work scientifically …”

C “See [unclear] skills makes it feel like it’s practical, like, hands on. Actually your ability to titrate or your ability to do this … “

B “Some trips are like that where you do that, so like the Chemistry For All projects absolutely enhances so they use spectro [unclear], they use titrations.”

C “But does it also support working scientifically though, that’s the thing. For me the two terms are interchangeable.”

B “I don’t know. I think working scientifically incorporates practical skills but I think it also incorporates other things.”

C “So you’re saying practical skills are more specific.”

B “I think the fact that it’s used ‘enhanced’ makes it different to me.”

C “Oh okay, yeah, yeah.”

B “Working scientifically is not all practical …”

[Talking over one another 29.30]

B “… evaluating, all that sort of …”

C “Also ethics, morals, all those conversations as well.”

examples of enhancing

C “It’s like the enhance the practical skills is you look at the aquaponics stuff that they’re doing, that doesn’t link directly to our specification in any way, it goes beyond it but I think it’s definitely helping the pupils enhance those skills.”

above and beyond

B “I think that should be there.”

B “I do.”

B “Yeah it definitely should be there.”

Battle of curriculum/exams v. building skills.

A “So just, I mean, like, obviously, you’ve given me feedback which is great, if you’d change it in any way, if there’s anything you would add, you can add anything or, you know, as a teacher are there aspects that seem like they wouldn’t be viable, like, if you said to someone coming in to go and work with 11 year olds, we want it to link scientifically, consider role models, do you think I’m asking too much?”

B “No.”

B “No. Not at all.”

C “Year 7, I mean role models …”

C “I think it’s really good cos I’m Head of Faculty, well Head of Faculty, but, erm, if I was looking at a vision, if I wanted to present to my department a vision for why I would like to do trips and how that would look differently across the years I think that’s really nice.”

HoF likes the model.

B “Yeah.”

C “And …”

strikes a chord with leadership which means that it is going in the right direction

A “And I think it was interesting what you said when you said about that’s why I didn’t put ‘go to uni’, at the top it was mentioning ‘next steps’ because the next steps might not be uni and I think that was something that maybe it, cos it is about, it’s about pride in the career pathway really.”

Make these experiences accessible for all eventualities. Not “one size fits all”

important the model is inclusive for all journeys

B “I think as well from our location here, erm, we are getting employers now who are pushing apprenticeships so Unilever which is just down the road, erm, now they’re offering, they are offering apprenticeships to 16 year olds. Erm, so that, that, yeah, I agree, totally cos I think if you did put, erm, access to uni or whatever, I think it would put a lot of people off.”

apprenticeships

links with industry

A “Hhmmm.”

usually don't have a strategy for trips

C “I think at the moment, like, trips in most schools would, you wouldn’t think of them strategically, like you haven’t on here, it would almost be like a free for all, anyone wants to go on a trip, great, go ahead with it, I don’t think we’ve ever sat down or many schools have ever sat down and gone ‘right, here’s our curriculum

I will explain trips

Not a negative - maybe it hasn't been done or maybe it just hasn't been shared with the teachers. Consider importance of communication & show that designers of programmes are aware of school needs.

for the day they walk in and the day they leave at 18, how will that look differently, what are we going to do with those years?' cos we, in a sense we've done it accidentally that, Year 7s is a trip to a museum, that is hitting those things but we haven't, so we've actually done it without even realising really but not to the strategic level of saying 'right, so those same kids, what are they doing in Year 9 that builds them up?"

B "What do you mean I've got one of these at home, every time …[all laughing]."

C "I didn't realise, yeah but it's almost how is that being built upon?"

A "Just as a side note, what do you feel, obviously, like, this is more that I've read than kind of the experiences you've said, that in, what the teacher and parent aspect is, what do you feel about, kind of that? Obviously you guys are …"

B "We've took a few steps to try and involve parents haven't we, like you did your STEM evening and we got parents in with that."

C "Yeah the parents' feedback from that was, cos we got the parents in with a group of students, er, and they did fun challenges for the evening and the parents' feedback was that they realised they could support kids at home without, in more fun ways so, you know, we made these pasta towers and parents realised afterwards 'well I can go home with my child and make a pasta tower and actually they'd be, it would help them in their education instead of just helping them with their maths homework tonight' So maybe realising they can do some fun things with their kids and I think a lot of the parents didn't even realise that there was a link between having fun with my child and …"

B "And doing revision."

C "So I think parents fed back to us that they really liked that for that reason."

B "We do, like, a curriculum launch in Year 7 don't we, well I don't know if we do it most, what year group it is but yeah, we show them, the parents come in and we tell them how to access the on-line systems we use and stuff like that and how to support with homeworks and things and give them a gist of what we'll be covering in that year. I think there's still more, in terms of the trips, there's always more you can do with parents but it's getting them on board isn't it and them having time and stuff to …"

B "Yeah. I think something we could develop as a department as well is making better links and partnerships with companies, like, you know, having, like taking advantage of [unclear 33.51], like Unilever coming to us and I know we do it on trips cos we go and see them in Big Bang and stuff but if we could get them in more regularly as part of our schemes and stuff, that just might make it a bit more alive for us."

C "I do think that's the hard thing about being an 11-16 school though because I find being in my last school [unclear 34.08] and I find being here, not at department level but whole school level, it's like get them to 16, get them their GCSEs and so I don't know if the career advice stuff, I think if they had a sixth form here I think the school would choose to emphasise more some of those, some of those things are important."

B "They do get, they do get a lot of, erm, guidance, I just mean …"

C "I think with, like, yeah, from the science point of view, these kids go off to somewhere else and when they go somewhere else then it's more important maybe at 17-18 they've got those links with outside agencies."

B "We're making them from being Year 7 …"

B "Sorry …"

B "I was just going to say if we get the links from Year 7 then when they do leave I know we're not responsible for them anymore but then we've hopefully instilled in them that, like, thirst, that want to go and look at more links and take advantages when they do go to sixth form."

B "The other thing I might add, which I've toyed with and done bits over the last few years, I've not put a lot of heart and soul into it if I'm honest, erm, I've done, in Year 7 I've done a parent audit, so every Year 7 kid that comes in the parent gets, like, an audit of things that they used to do, anything the skills they have that they'd be willing to offer us, what their career is and what they'd be willing to come in and give us a talk on different stuff. There's been no scientists as of yet [laughing]. I always scan them and if they've been into primary school doing reading or, you know, if they've given up now, cos in primary school they do don't they, volunteer so it would be worth in that parent thing so is there a way of people finding, of schools finding out cos they might end up having a wealth of knowledge on their doorstep and people willing to come in."

A "And just, I suppose, obviously I'm aware of the time, erm, one of the groups of pupils that you have mentioned that I want to kind of put a focus on is, like, pupil premium, so looking at this model now, erm, do you think there's any, like, specific areas that are the most important, like if we were doing one that was specifically focussed at this group of students that we need to focus on or do you think there's anything you would actually specifically add for that group of pupils/"

C "I think role models."

B "I think role models are important."

B "Getting the correct role models as well, so getting role models who've come from similar sort of backgrounds from what they've come from."

B "People who they think they associate with and try and get …"

C "What I did as well was I think they need to know how it links in their life cos their life might be very narrow, their only experience is community, so having scientific links actually affecting this community, it's not like you go to London or you go here, you know, you leave, so …"

Discuss starting their experiences at a much earlier age to make the more the norm.

Start these links early

instilled from an early age

has an impact on choices

- goes against questionnaire

try and utilise what parents can offer

importance of parents more

Utilising parents

PP focus.

Highlight Role Models

appropriate role models

relatable

relatable / similar background role models

relatable

Gives context to real life

broaden minds

relatable to their community

relatable role models provides more relatable experiences

important when trying to engage more disadvantaged learners.

C “Well when I taught, cos new in the curriculum now and I’m surprised how interested the kids were when I taught about Wifi and about radio waves and about how blue tooth works in your house, like I’ve never seen them, like, my 10 step forwards [?] are really challenging and I’ve never seen the boys so interested. They were like ‘wow, so this is how the Wifi gets from here to here?’ and suddenly it’s the first time I’ve kind of taught something that they can relate to in the classroom. I’m pretty sure if I had turned round and said ‘we’re going to have a trip and speak, go to a technology company who deals with, like, Wifi signals’ they would all love it because that’s something they suddenly, it related to something that they do. It’s relevant to them. Internet is relevant to them and it’s a new part of this curriculum that I didn’t teach the first time round I taught the Year 11 but the Year 10s this year, I re-planned the whole thing cos I wanted to have more of a spin on it being, like, real context and I think with that, the curriculum doesn’t always lend itself to, like, new 21st century science does it? When it does that’s really, really good but I think, yeah, role models. I think for the youngest ones, people enthuse and engage, I think it’s to start them young cos you have to have them there. If you haven’t got, if you lose that too early, you kind of, you’ve got a hard battle then.”

B “I think as well if you didn’t have parental support we’d struggle, so I think that is an important one but I don’t know how we go around getting …”

C “We’ve had issues before where we’ve had trips where we were competing to go into a national level and we had a child, we were in the school and a parent had pulled his child out to play a football match whilst he was representing the school in, like, a North West … we ended up winning the whole thing and going to London to represent the whole North West of England but the dad pulled him out of it during the day to play football. So seeing that he was doing really, the kid wants to be an engineer, wants to be a scientist and his dad made him play football.”

B “I remember in our old school where we’d done something similar and the boy was in my form and he was 17 and he’d done an amazing job, he got through to a final and the parents pulled him cos they insisted he had a 24 hour chaperone, erm, and we said we couldn’t provide that. We could go with them, spend the day and come back and they weren’t happy cos they didn’t feel, his, like, safety was being considered enough cos he wasn’t 18 but we were saying it’s not exactly us who’s organised the trip, we’re just putting him forward for it. We’ll write a risk assessment even though we didn’t have to, do you know what I mean, it was one of those type of things. So, sometimes that can be a bit of a barrier, like, I suppose us not having that easy communication with parents or them an understanding of what they’re entitled to and what they do on a trip, do you know what I mean?”

A “So how do you, I suppose, in that sense, the parents side of it, for pupil premium kids the parents is probably important and what do you think in your experience, cos it sounds like you do do events, what do you think would draw the parents in then, these parents of these kids?”

B “We’ve got loads of experience with that.”

B “Food is always a good one. So any event that you put on, if you put a hot chilli on or a hot pot, a chilli blows your mind usually but anything like that, erm, crèche, cos they’ve got younger siblings that they can’t leave at home and stuff so if you’ve got prefects and things like that, they can look after the young ones then that means they can bring them with them, anything like that make a massive difference on whether they’ll come in or not. And then we’re really lucky here cos of the funding. I bet a lot of schools, the kids can’t go because there isn’t the money there. A lot of parents can’t pay £30 for a trip for a year or £20 a trip for their, erm, I mean we’re really lucky cos we can put bids in.”

C “Well I suppose the more kids you’ve got the more money you’ve got and I find …”

B “But a lot of schools don’t allocate it the way we do. A lot of schools buy computers or, you know …”

C “Quite often though the schools, the less kids a school’s got, the better those PP kids do because they’re not surrounded by large amounts of PP kids. So if you’ve 5-6 kids, PP kids get into a grammar school, they’re around kids, so, we always find, looking at the data, when PP gets get into trips Science do really, really well, the kids have found themselves in top sets, from a very early age and have always surrounded themselves with other kids who are aspirational and got parents that have got … yeah, they tend and PP also at the top end and also really, really good and that’s not necessarily something we’ve had to do, it’s because they’ve found themselves in that group from day one.”

B “With your PP stuff as well, erm, we find it makes a massive difference not sending letters, cos they just don’t get them. Erm, text messaging makes a huge difference. I text all of them.”

B “I didn’t know that.”

B “I text all of them now and get responses straight away, they text straight back whereas … but a lot of them aren’t on, you know, when we have parent mail, the e-mails that get sent out, a lot of, if you look at the PP kids that have signed up to parent mail and the non-PP, we don’t even have the e-mail addresses for a lot of the PP parents.”

A “But you have phone numbers?”

B “Yeah, we have phone numbers on the system but they won’t, you know when they come in, they don’t, they’re very reluctant to put an e-mail address down whereas the non-PP always give, they’re quite happy to put everything down.”

C “They won’t answer their phones will they either.”

B “They don’t necessarily answer the phone.”

C “The school text message thing.”

B “Yeah, they don’t answer the phone, they also don’t, erm, if you leave a voice mail, because it costs money to get your voice mail, so a lot of them won’t even pick up messages. So things like that that you don’t necessarily think of, makes a difference.”

B “So if we’re organising trips and they’re all PP, send a letter and a text.”

B “I’m still arguing with the Head over who can send what. [laughing] We’re getting there.”

C “We’ve had a situation where we did the STEM challenge and we called every parent.”

B “Yeah, yeah.”

C “We had 20 kids who wanted the target and we all took up the kids each and we called every parent and that was the best way of making sure that we, and I’m pretty sure that if we’d just sent a letter home we wouldn’t have got anywhere near the participation that we did.”

B “That goes back to what we were saying before, the challenges, we said time but part of the time is chasing up those letters.”

C “What’s interesting is we had one parent in, we didn’t know much about, the Head was here at the time and the parent had been in for, like, permanently excluded from the school, you know and they brought their kid to this STEM evening and the Head was oh, a bit surprised that this parent was here but they got a personal phone call from us telling them that their child was really, really good at something, blah, blah, blah and they came in. But it was funny that you had a parent that almost disassociated themself form the school and they were here and now they’re like hang on a minute, the school are investing in me and my child’ and I think if we hadn’t made that personal kind of conversation, connection they wouldn’t have, they probably wouldn’t have turned up.”

B “The time of day is always a really good one if you’re dealing with PP, not necessarily just PP but, erm, like when we’ve ran activities in school, not necessarily in science but I presume it would work the same if we did one in science, we do them of an afternoon and get the kids of timetables so they can do stuff with the kids together in the afternoon, rather than them having to give extra time in the evenings or …”

[Tannoy announcement]

B “… at the same time they don’t have a lot of commitments.”

C “Yeah, it’s hard in the evenings, you’ve got all the kids in primary schools haven’t they so they can’t bring them all in.”

B “Sorry, we’re gonna ….”

A “That’s fine, we’re at the end. So just basically, you’ve got my e-mail, if there’s anything else you think of or want to add, I really, really appreciate …[talking over one another] … it’s got a little inventory in there, just, they’re all from [Timstore?] if you want to check up.”

B “Check up [laughing].”

Focus Group 4

A	Interviewer
B	Participant – unsure (female)
C	Participant – female
D	Participant – female
E	Participant – female
G	Participant - male

A "Great. Erm, so, where are my questions? Okay. So if I said 'science outreach', what does that mean to you guys? Just …"

C "Support. Support or …"

D "Usually from external sources coming in."

C "Either coming in or somewhere you can go. Sometimes we've had some really good science outreach where we've gone out to schools, high schools have provided …"

A "And what kind of stuff have they done there?"

C "We did a whole, erm, it was a whole day and it was at Ridgeway and we did about, a lot of it was about germs and how, cos they did one where, erm, they mimicked somebody sneezing and how far the snot flew [laughing] and the children loved it, so it's that type of thing. We've also done one about, erm, many years ago but it was fantastic, about forensic science."

A "Okay."

C "And they gave us a box that we could then bring into school and it was done as a transition project between primary and high school and then we brought the project back to school and we loved that and then the box was just stopped, we didn't get'em any more."

A "Anything else?"

E "We've been on a science fair haven't we?"

D "Yeah was that the one …"

E "And the children sort of did around four activities, some was in the laboratory and they were doing some, a, was it alien blood or something and they were matching, so they were adding chemicals …"

C "Something about adaptation as well and the time line, the toilet roll …"

A "Was that at another school?"

C "And then we've had Science in Literacy stem coming in haven't we."

D “The stem team have come in.”

C “Working scientifically course and then some of us, I didn’t go on that but went to …”

D “We went on some CPD…”

C “Park Primary we went to.”

D “Which was really, really good.”

G “Yeah.”

A “And so what do you think, like, the general benefits are of these, these types of activities for the kids are, for yourselves or …?”

E “For the children, well, for ours when we went to that science fair, it was having access to a laboratory and all the materials …”

D “And equipment.”

E “And the technician who’d set it up was, you know, to do that in a primary school classroom is really difficult.”

C “Using data loggers and different things wasn’t it that were just there.”

D “So just tapping into those expertise and expensive resources and that there was enough of them, that’s the other thing, so we’ve had data loggers before but we might only have had a pack of six so be able for everyone to do it at once.”

E “And do you remember the pulse meters as well, we were doing the heart and they never worked. They gave really strange readings and sort of trying to, it is, it’s just …”

D “And also it’s little moments of ideas where you can, ahem, little light bulb moments for us that we’re ‘oh yeah, I could use that’. So it’s just, you know, little ideas.”

C “Bring science alive a bit.”

G “Yeah.”

A “And do you think there’s any negatives for kind of engaging with the types of programmes?”

E “Cost for us. It’s always down to cost. So we have these opportunities or have had these opportunities and it’s whether we can, I mean, with the Ridgeway they part funded the transport so it was half and half but for us to transport, the coach …”

D “They used to call those schools, it wasn’t ‘excellence in cities’, what was it?”

E “But it cost, like, £4 for a coach, per child, so it is literally cost to our parents.”

C “And the CPD we’ve had, thankfully, has been free hasn’t it, which has been really good.”

A “So are they the kind of things that stop you from …?”

C “Definitely funding.”

G “Yeah, the funding, definitely.”

A “Yeah. Erm, so which groups of students do you think particularly benefit from these, these types of programmes?”

D “I think all the children do.”

G “Yeah I’d say any.”

C “Yeah I mean they do, the only ones that have had access to going out to those labs were the Year 6s weren’t they, because it was part of that transition so a lot of the younger ones don’t necessarily get that opportunity.”

D “Cos I can remember we did it with Year 2, I mean, we took Key Stage 1, that was when I went and we were doing lots of it cos I’ve got pictures of the Year 6s now and that’s one of their memories, of doing that in Year 2.”

C “Ah okay.”

E “Isn’t there, well that speaks for itself then doesn’t it, if four years later that’s one of their special memories. Didn’t Year 4 do some digestion or something as well …?”

C “In their classroom?”

G “Oh yeah.”

E “Didn’t they go out first and then they came back and maybe they’ve not done it since. I think again that was Ridgeway.”

A “And do you think pupils want to be, like, want to be involved in these programmes or …?”

G “Yeah. Definitely.”

C “Oh yeah, it’s something different.”

A “And what do you think, how do you think it impacts on them as, like, I don’t know, have you seen any impact or …?”

D "Just bring science alive for them doesn't it, instead of it being something that you just maybe do once a week, it's quite exciting isn't it, it becomes a bit more exciting."

C "They're active, not passive."

A "Yeah. Erm and do you think, well, maybe you've kind of touched on this but do you think they remember them or …?"

G "Yeah I think if it's just one block of a day it sticks in more than that one lesson they have that Wednesday afternoon."

C "If it's going out somewhere it's always exciting anyway isn't it?"

A "Yeah. So, I mean, have you been on any trips out anywhere other than the feeder school or …?"

D "Science related?"

A "Hhmmm, yeah."

D "We've done the museum where they go to do the …"

G "Planetarium."

D "The Planetarium."

A "Oh yeah."

D "We've had actually the Planetarium in here haven't we, set their stall out …"

C "Oh yeah, that was years ago that wasn't it."

E "And we've also, erm, accessed, er, Arrow Parks and people have been to Thursteston and done pond dipping, that's been in the past, not recently. Although recently we've just been to Arrow Park, erm, just on a, like a nature walk, so that was early years cos we're ..."

C "We did Hillbury was we, we did it cos we had a two week programme called Coast to Country about plastic and, you know, saving the environment and everything and lots of us did different trips. So three years, 2, 4 … 2, 3 and 5 all went to Hillbury, erm, and we looked at different features along the coastline there."

D "And we've also had the life caravan, the life caravan was really good wasn't it where the children used to, it was all about me wasn't it, at different levels of understanding and it was about, I suppose it would have been animals, including humans."

E "It was drug education, it involved lots, so it was a cross over between science of PSHE and …"

A “So they came here and then …”

D “Yeah it was like a big van so they’d go in and they’d have videos to watch and models. I don’t think you were here then.”

G “I think I remember doing it when I was at school [all laughing].”

A “So it sounds like, do they happen quite, do you think each year group get some sort of experience each year or …”

G “I think it’s getting less.”

D “Much less, yeah, not as much as it used to be.”

A “And that’s mainly to do with funding, of course. So, er, I’m going to share with you now, er, the model. Now, there’s currently two versions of it, erm, because I’ve had a few, a bit of feedback from other schools, so this is where I’m working at now. So I’ll just explain it so you’ve got a bit of, kind of understand what’s happening. So it’s like a cascade model, so it, it builds on what you’ve worked with. So we’ve got the kind of age brackets, so if you’re working with this group of learners up to, you know, up to 5 year olds, they use the kind of, it’s basically advised for people, anyone who’s, you know, schools, museums, people coming in vans, what you should be thinking about when, you know, you’re devising these programmes. Erm, and you’ll notice also it has, like, erm, teacher and parent involvement as an opportunity when you come in and do these activities too and maybe how to support them, involve the parents too. So, erm, what, maybe I’d like you to do, there’s some questions here about that, erm, just for a few minutes, oh and on the other side it was suggested maybe the shape, I’m not as tech savvy with that but you can see what I’m trying to achieve and obviously I’d change that. So, erm, there’s just a few questions there. I’ll give you a few minutes if you want to kind of annotate or discuss between yourselves or if you’ve got any other questions, erm, what you’re thinking. So …[long pause] And these here, these are themes that should run, actually, kind of … and obviously for you guys, you know, especially the younger input as well, that’s something that has changed dramatically since talking to other primary schools. So it would be really great to see if that, that’s, it translates as well, erm, with what you’re kind of doing.”

C “I think it does look logical, a logical progression of skills but I would say that I still would think that I would like to see, erm, some of the Year 5s or 6s or Year 4s still doing these.”

A “Yeah. So what happens is if you were working with, let’s say the 12 year olds and you’re looking at careers in science, you’ve still got to do all of those, so it builds and so the point where you get to, you know, the kids are in college, you are mentoring the next steps but the programme even just have problem solving …”

C “All the way through.”

A “Yeah. It becomes more focussed to building a scientist but at the time, just, yeah.”

E “I don’t know whether it’s just our school but I know, erm, as a leadership team we’ve been looking at vocabulary so that would come into scientific and it’s a big drive at the moment isn’t it, the curriculums are moving, so I don’t know whether that …”

A “Something that could … yeah.”

D “Scientific vocabulary.”

A “Yeah, no, that’s great. Erm, …”

C “I mean, that would probably run through all of that…”

G “Yeah that would come from the start wouldn’t it.”

C “… something that you would have as an extra add on.”

A “Yeah, it definitely builds on throughout.”

D “Because when children try to explain things in science they’re not using the correct vocabulary.”

A “And that, that happens with most throughout as well because most, you know, so many words are used in everyday context, science as well. Erm …”

D “You know when you talk about up to 16 and new experience and context, what does that mean?”

A “Erm, so, I suppose that’s more, like, if you’re going to go into maybe the college or, you know, it’s placing everything they’ve learned into more of a formal context maybe, like, industry as well.”

G “Oh okay.”

A “Erm, I do see that probably can apply to a lot of …”

D “Yeah I was gonna say, I can see that up to 12 to be honest cos I think the early capture there, they’re looking at careers in science but I think the more that you’re giving them, different experiences and something to aspire to.”

E “I think linking into that as well, children seeing early on real life applications of science, so why it’s important.”

D “I do.”

G “Yeah.”

C "That Coast to Country project, erm, two of the children in my class got to go to Landrover and they looked at lots of, er, it wasn't just science but the technology behind how they save plastic really, recycle and then the Year 4s went to Biffa, the waste place and that was, erm, I think they were really valuable experiences and I know the two boys that went in my class, they just got picked if they were the school council members basically, they were, like, really enthused when they came back and obviously they were 8."

A "Yeah. I think, like, that's it, it's like trying to go through to the role models, the career and the context, they're all basically kind of the same thing."

G "Yeah."

A "But becoming more formalised. But no, I think the context is definitely something. But, yeah, just come at me cos obviously I want to change it based on, erm, what, what I hear from you guys. Erm, is there anything you would, anything that doesn't seem reasonable or viable? Obviously you're not asking them to do it all at once but, like, you know. Erm, now, look, thinking about this model now, one of my focus groups of students is those who are in receipt of pupil premium, so those from lower socio-economic backgrounds and if you were devising the programme and using this model, I guess, to guide your programme but you've been told you're working specifically for a school with lots of those learners, what do you think would be the most important aspect points maybe of this? Is there anything that you would, that's not there that you think if you're working with this group of learners you need, like, is there anything?"

B "So for those pupil premium?"

A "Yeah, so what, what do you think are the key, if you were to just cherry pick some of the few …"

B "Of use and engage."

G "Yeah definitely."

C "Promoting play, hands on, practical, lots of practical skills."

B "Just to get that interest going."

D "Raising aspirations and then linking that with professions because a lot of, erm, there's lots, just making that discovery that jobs in science are not just for your doctors and your professors but things like hairdressing is a science, you know, so there's a huge, that wide variety of sciencey stem jobs out there that are open to everybody and that they're not just, erm, they're not just cherry picked for the ones who have to go to university and things like that."

A "Yeah exactly."

C "I think also for all children, not just the pupil premium, it's the parental input …"

G "Yeah definitely."

C “… and, erm, I know that, as a school, we’ve stepped away from homework a lot because of pressure on parents in terms of time and, erm, that, that’s, what were the children actually getting out of homework anyway? Did it bring anything to the experience? So I think that’s just sort of an interesting thing really for me.”

A “Yeah, that’s something that has popped up, kind of, I’ve been, you know, told that if you’ve got the parents on board, you’ve got, you know, it’s easier then for anything you want to do.”

G “Yeah.”

C “I think it’s really difficult for lots of parents now isn’t it, cos they’re working til later at night, erm, you know, and it’s what do you want the children to be doing with the parents, do you want them to do, it depends what it was that you’re asking them to do, you know, you want them to spend quality time together.”

A “Hhmmm, yeah. Anything else about working with this, like, specific group of learners?”

E “I’d just put for the 5, up to 5 year olds, something about exploring, investigating, I know you’ve got problem solving and promoting play hands on is implying the exploring and investigating but that’s, …”

A “But make it …”

E “Yeah, make it a bit more explicit that they’re not, they’re playing purposefully.”

A “Yeah and what do you think about, obviously the, the circle shape, I’d get some help with that [laughing] but do you think, cos that’s one thing that was discussed in other groups, I mean, …”

C “So is this a representation of this, in a different form?”

A “Yes.”

C “For me, it just doesn’t make any sense at all.”

A “No, okay.”

D “That one makes … I prefer that one, but I can see that one makes it look more as one.”

G “I think that one actually works better coming, starting off from the middle and working outwards rather than working into the middle, it kind of feels like you’re going down a little black hole.”

A “Yeah, okay, yeah.”

G “But if you’re coming outwards and building on outreach …”

A "Yeah."

C "I find that really difficult to read."

C/D "Different people."

A "No, no, that's it, that's what I've been trying to do, like just say 'okay I'll do this' and then the next group I'm like 'what do you think?', erm, …"

E "I was with you guys cos I'd read it wrong."

G "Yeah, I read from the inside outwards."

E "Yeah I thought that was the core, so that would be, cos you said it builds out …"

A "Yeah, I think that's where you focus in."

B "That's where you're building to."

B "Yeah."

A "Yeah, no, I think, I mean, I'll have a little look at that actually but, yeah. Erm, erm, thanks, yeah, anything else that you think might be of use to me? You can see obviously what I'm trying to do, rather than writing a list of recommendations, it's kind of a visual representation of … and what, what do you think about the teacher, erm, segment? Do you think that kind of, so basically what that means is if someone was coming in and offering a bit of CPD as well, like, is that the kind of, or like if during the programme you're going to provide resources?"

G "Yeah the biggest thing that we've got out of the stem stuff, this year, is just what's actually out there cos …"

B "There's stem ambassadors and things like that we didn't know about."

G "Even just simple things like the explorerfy website, I've used that so much since we found out about it."

B "Me too."

G "And it's just so simple to use but obviously had we not gone on that we'd never have known."

A "So it's when people come in or you go out, it's being able to say, just signpost a few things."

C "Yeah, things that are really useful that you can use straight away, you know, often just one simple thing can make a massive difference to your teaching and, you know, I think that we haven't got the time, you know, everyone's pushed for time when you're teaching, as you know, so if somebody can just give you something simple and practical …"

D “I think when there was a bit more time you used to be able to explore a bit on the web and find stuff but you tend to revert to what you know.”

C “And because everything’s small, cos we were talking about data loggers and there was an app for that, cos everything has gone more towards technology, to record things, so it’s more important that we know about, that it’s accessible to us, and it’s there, you know and we can use it. Cos if you’ve gotta bring things in, it’s a bit like, I mean I used to find those really useful, where they’d come in with a box and it contained everything you needed to teach that subject, that used to be fab didn’t it, really useful. But I think also just from going up to your 16 year olds, just being a bit of devils advocate really, in high schools, lots of times, teachers, non-specialists are asked to teach subjects, so it could be that CPD still needs to be there too.”

A “Definitely.”

D “I know that.”

C “You know, exactly, you’ve got the PE teachers teaching science for the next month or whatever and it happens doesn’t it.”

A “Of course, yeah.”

C “So I think just more general CPD up to 16 as well.”

A “Fab.”

E “And working alongside colleagues as well is great isn’t it.”

G “Yeah.”

B “Having the time to talk.”

E “… opportunity to work with a forest school leader and you just pick up so much so it’s being an observer and having time to write notes and things.”

C “Having those professional conversations.”

G “It’s sharing good practice.”

A “Erm, well thank you.”

B “Thanks very much.”

APPENDIX M: VIGNETTES FROM EACH FOCUS GROUP

Focus Group 1: Secondary school science department

In this focus group there were seven participants from an 11-16 mixed comprehensive school in the NW of England. The school is in a socially deprived location and there about 40% of the pupils who are classed as 'disadvantaged' which included learners of a lower SES England (Gov.uk, 2020). This meant that even at the start of the focus group, when the questions were not directed at disadvantaged learners, participants emphasised the importance of engaging these learners' with outreach activities as "they're seeing kids from other schools and its giving them a boost…that they're capable of doing those things". Participants also highlighted some pragmatic issues regarding attending outreach programmes outside of school grounds as they described how " leaving the school is one of the biggest things for some of them". The participants also highlighted the wider benefits of these activities for both staff and pupils as a way to foster relationships and an increased awareness of other skills the pupils they teach have, and that these events raises the profile of science across the school. The participants explained how these benefits had been an outcome from their recent pupil voice survey and how pupils had highlighted that they wished other departments also organised as many events as the science department do. It was apparent that this department did regularly engage with outreach activities as they drew upon several examples from their current school as opposed to fewer in their previous teaching positions.

The department were generally positive about the draft model and their discussion confirmed which aspects of this would resonate with their pupils and provided examples of this. For instance, the inclusion of 'role models' within the model sparked discussion about films and trips that focused on women in science and how the "pupils on the mini-bus on the way home were buzzing". The constructive feedback highlighted the term 'working scientifically' and the readability of the model. As they did not teach post 16 courses at this educational establishment, discussion regarding Post-16 were anecdotal however, the teachers did highlight the significance of supporting pupils who might not want to go to university and supported the notion of 'mentoring the next steps'.

The last part of the focus group did ask the participants to focus on the model in the context of 'pupil premium' students. They were able to suggest which aspects to the model would have the most significant impact such as the inclusion of the parents. It was highlighted that "if you didn't have parental support we'd struggle' along with situations where this had been the case. Whilst the model did address how parents could become more engaged, the participants provided suggestions of how to facilitate this and highlighted that it was more productive to communicate with parents via email or text and not via a letter. Therefore, this should be carefully considered when targeting disadvantaged learners for science outreach events.

Focus Group 2: Primary school

This focus group consisted of nine participants who taught science as part of the primary National Curriculum (DfE, 2013) from EYFS to upper KS2. The school is located in a socially deprived area of the North-west of England and about 45% of pupils are identified as 'disadvantaged' England (Gov.uk, 2020). At the start of the focus group there was some confusion as to what the term 'science outreach' meant and after a brief explanation participants began to realise that they had in fact engaged in these types of activities quite a lot. The examples highlighted how a lot of these activities involved trips that were outside the school grounds such as to a farm or museum, but there were also some examples of programmes that were delivered on school premise "we had zoo lab come in and….we did life cycles". These activities were exemplified across the whole age group in the primary setting.

During the initial general discussion about science outreach and the model itself participants were often linking the activities and the focus to the National Curriculum (DfE, 2013) as these teachers described how "the national curriculum is king". Participants discussed how if it directly did not link to the formal learning then it would be unlikely that they would participate with the programme in the first place. It was discussed how those who deliver the outreach activity, whether in or outside school, are perceived to not have as much awareness of the schemes of work so the participants described it would mean they would have to make these links. Participants also described how they thought that engaging in outreach programmes was part of their role as a teacher rather than an extra-curricular activity as it was said that "I don't really think about any of that stuff as being separate to the curriculum, for me it's part of the curriculum". Thus, the participants identified how the model should reflect links to the curriculum and that those who use the model to assist the design of future programmes should be more aware of this.

Another important point raised by the group was the opportunity for these science outreach programmes to support teachers too. It was discussed how although they are able to make clear links to the curriculum it would be conducive for these outreach opportunities to create more 'wow' moments, as teachers can struggle with this in a primary setting often due to limited resources. In addition to this, CPD that is currently offered to participants within this school often focused on "how do we deliver the curriculum or how do we get these objectives rather than how do we go and look at these trips you can go on….I don't think it is well publicised or advertised". Considering these last two discussion points the model was modified to address this.

During the last part of the focus group, the participants outlined the importance of using these opportunities as a chance to see their wider community "because they may be less likely to get those experiences". There was also an important discussion regarding the labelling of children as 'pupil premium' as a measure for social deprivation; participants described how there are pupils in the school that for one reason or another do not have this classification but they still live in the same area and have the same opportunities and their pupil-premium counterparts outperform them. These ideas link to discussion surrounding an 'opportunity gap' (Morgan *et al*, 2016) in 4.2.1.1 and also the 'Unlucky Child' (Ofsted, 2013) in section 5.5.

<u>Focus Group 3: Secondary school science department</u>

In this focus group there were nine participants from an 11-18 mixed comprehensive school in the NW of England. The school is in a socially deprived location and there is just slightly under 50% of the pupils who are classed as 'disadvantaged' on role at the England (Gov.uk, 2020). The participants within the focus group were familiar with the idea of 'science outreach work' as they were able to confidently identify some partnership programmes with universities, medical schools and events that have taken place such as 'Spectroscopy in a Suitcase'. Throughout the focus group discussion, this group of teachers did highlight the benefits of outreach work such as; 'raising aspirations' or 'making it real' and talked about how 'the kids loved that'. However, there was a noted tone throughout the whole focus group that the relationships between schools and outreach providers had the potential to be quite complicated. For example, it was described that outreach activities are "when people come in and do the experiments that we want to do with the kids but we either don't have the funding to do them or we don't have the time during the curriculum time to do it. So, people come in and have fun doing things that we just have to teach on the board".

A lot of the discussion centred upon what science outreach activities can do which they as ‘normal science teachers’ could not and what gaps it could help to fill in the curriculum. This meant that participants were honest in their evaluations of some of the events they had experienced and were open about what they feel the programmes need to do be improved, as discussions highlighted that not all of these events were deemed to be successful. It was mentioned on several occasions how facilitators of the outreach programme need to be more aware of their target audience and be able to make sure that the activities are differentiated for this group of learners. It was also suggested by participants, that the relationships between outreach facilitators and the learners can be very positive and that ‘outreach, which is kind of more sustained, is better’. The focus group discussed an example of a more longitudinal project that they are involved with and whilst again there were lots of positives, there was also a sense of the ‘cost’ of both money and lesson time of being involved in the partnership. It was also outlined how outreach programmes are great ways to promote careers in science and due to changes in school systems that they could be responsible for providing more work experience placements.

When discussing the model this refocussed the conversations to look at the potential of science outreach programmes and there was a positive response to the inclusion of involving parents and how the introduction of the stages can encourage those who design these activities to think of their audience and objectives. Participants also highlighted how these should not just be simply recruitment events as it was depicted how "… I think some companies like [name of company] maybe have their own agenda which is just ‘let's get them into a job." Thus, the participants liked the use of the language within the proposed model as it wasn't just focused on the ‘academic’ route into STEM based careers. The participants also discussed the inclusion of younger aged children, which was welcoming considering that these participants worked at a High School. They drew upon personal experiences of having younger children and highlighted how having the idea of ‘focusing upon role models’ from a younger age is important. The points to consider about the model itself were the use of the language of ‘enhance’ practical skills as there were some query about what this meant and at what age would it be important. Therefore, it was considered that it would be useful to have some sort of a ‘guide’ that accompanied the model to make sure it is not misinterpreted.

When focusing the model on a specific group of learners there was a clear discussion regarding ‘raising aspirations’ and ‘parents’. The participants discussed how in general they found parental engagement was low within the school and again thought that science outreach initiatives could help to assist with this. The participants provided an example of how when this does happen such as at their 'open evenings' it promotes further conversations between the parents and their child and the participants saw this as having a positive impact. This aspect of the model was particularly valued for all learners and they agreed with engaging parents at all educational levels but suggested that it became more difficult the older the child.. Thus, this aspect of the model was further refined slightly to ensure that parental engagement ideas were appropriate for the age of their child.

Focus Group 4: Primary school

This focus group took place at a primary school, again within the NW of England but unlike other schools their percentage of 'disadvantaged' children was around 12% which is about 10% lower than the national average in England (Gov.uk, 2020). There were only five participants within the focus group but they were able to highlight an array of science outreach events they had experienced such as; forensic science day, a science fair and several themed days at local high schools. The conversation around these events were positive and in particular they noted that after one of these activities "they gave us a box that we could then bring into school and it was done as a transition project'. The participants really liked this but described how "it [the outreach event] just stopped" due to limited resources. This example was particularly important as participants also shared views about how they enjoyed engaging with these events as they can use it for CPD and for them to be able to become familiar with new equipment. The idea of teachers being able to take away some associated resources linked to the activities was met favourably by these participants and there should be worth considering as part of the design of science outreach programmes.

For the school, they again mentioned that cost was still a factor in being able to engage with these types of activities and they also eluded to the accessibility of projects. Though it was not specifically stated it was inferred that although the participants could list a lot of these events these are not that frequent; "oh yeah, that was ages ago wasn't it" and "I think it's getting less". They also highlighted in their examples how some of the classes "don't necessarily get the opportunity" to attend these events though. This links to discussion points in previous focus groups and raises the idea of who gets to attend the events and their target audiences. A participant from this focus group discussed how science outreach programmes help to make 'science come alive' and compared it to the 'normal' science lesson. However, this group saw this to be particularly beneficial and seemed to be less threatened that these experiences were more memorable. They also discussed that they felt the impact of these events was proportional to the length of the programme.

When looking at the proposed model, there was still a little confusion with the readability of it but after a brief description the consensus was that it seemed to be logical. The participants also suggested that the model should contain a theme regarding promoting 'scientific vocabulary' because 'as a leadership team we've been looking at vocabulary so that would come into science and it's a big drive at the moment'. Whilst this a reasonable suggestion, the main aspect is to consider that all schools have their own agenda and focus and that the proposed model will not be able to respond to all of these. Additionally, outreach programmes will also have their own remit too and this might not always align with the school improvement plan. Thus, if science outreach programmes are to become more impactful and effective in engaging learners in STEM then there needs to be an awareness of these different agendas of the creator and the audience. Participants' discussions also centred around how outreach intervention needs to be focused at a younger age range, as 'children seeing early on real life applications of science is so important'. The model proposed does aim to encourage this and supports the inclusion of the earlier level within its design. Teachers also highlighted that many outreach experiences were not just about 'science' and could link to other subjects such as technology. This approach places science learning in the context of the STEM/STEAM agenda and reflects the more holistic approach that is discussed in in section 2.4.

When focusing on the model as a tool to work with 'pupil premium' children the participants discussed how 'raising aspirations' was important; this reflects the points of previous focus groups but examples of how it is about removing stereotypes for this group of learners was stressed. The main approaches for working with PP learners centres upon the five foundations of the model and how it should be 'hands-on, promote play and practical science'. This focus group again highlighted the importance of parents and their involvement as it is important for 'all children not just the pupil premium' children to have parental support. The discussions involving parents actually focussed upon reducing the pressure upon parents and how in doing so you can 'get them on board' and how 'it's easier than for anything you want to do'. Whilst the participants highlighted the importance of this relationship, they also recognised the difficulty to do so, but suggested that it should be something that encourages 'them to spend quality time together'.

Finally, the discussion focussed lastly upon how outreach opportunities can support teachers. They stressed how it can be a way for them to learn about new resources and it being an opportunity to talk to further professionals. The idea that these programmes not only supporting students but teachers in addition, is important as they themselves are gatekeepers and as workload is also described by this group as a barrier, then accessing the activities should entice the teachers too. Being able to 'share good practice' and 'have those professional conversations' could be what motivates a teacher to partake in outreach events, which in turn can have a positive impact on those learners who encounter them.

References

Gov.UK (2020) 'Find and compare schools in England' available online:

https://www.gov.uk/school-performance-tables?_ga=2.84103262.691597247.1581089822-201165548.1581089822 accessed 14th Oct 2020

APPENDIX N: SUMMARY OF STAGE 1 PILOT STUDY

Brennan et al (2018) published findings from their pilot study linked to this research. A summary of some of these points are highlighted below. The findings are collected based on the hypotheses discussed in chapter 4. The discussion from this pilot study was useful for analysing further data collected within stage 1.

What is outreach?

When asked the question above, 67% of the participants agreed that science outreach activities usually involves an external party. This could be someone who is not part of that particular school, either coming in to deliver programmes or the learners leaving the school to experience these programmes. For example, participant 1S described their understanding of outreach work to be *"when schools engage with external partners eg. Primary schools, universities or scientists"*. This response potentially outlines their view of their partnership with other stakeholders. However, some participants indicated the idea of an 'expert' outside support or the professional development of certain individuals, as participant 2S suggested it to be *"Providing expert science support to schools without expertise or who need targeted info/support"*.

Additionally, 27% of participants also described their understanding of science outreach as activities to provide a wider knowledge of science careers available within a real life context. This was described by participant 7S who suggested their understanding of science outreach work to be *"making school science more relevant to the world of work, new developments, types of jobs, motivation to further study and enhancing the curriculum."*

When looking at responses from question 6 which was an open ended question, there was a more varied response from participants. It encouraged them to draw on any themes from the questions they have answered (about their views of science outreach work) and these thus generated two new themes. These emergent themes linked to 'assisting learning and the curriculum' and issues surrounding 'the delivery of these programmes'. Teachers considered the potential of science outreach as a tool to engage and inspire learners, as 60% of the responses linked directly to these themes whilst 46% of participants connected these programmes and learning to the curriculum. These ideas are reinforced in the comment provided by this participant 7S who discusses how "engaging in good quality outreach experiences are very valuable for motivating students and good quality learning. The danger is that, as teachers are so overworked, the activities become forgotten." The response is also important when considering the aims of this entire research study; it highlights a teacher who see the value of outreach programmes but maybe cannot sustain these experiences for the students due to the increasing workload of the teacher.

Outreach and Pupil premium

It was found that 87% of participants thought that outreach activities were of the highest importance for pupil premium students. 77% of these participants also 'agreed strongly' that outreach programmes allow pupils to experience activities that they may not have had the opportunity to do otherwise. This is encouraging as it suggests that teachers feel that outreach activities in science are a valuable intervention tool for this demography of learners. It is also encouraging to note that the length a participant had been qualified as a teacher, did not affect their view of how important science/chemistry outreach activities were for pupil premium students.

When is outreach important?

Question 4 asked participants to use a Likert scale to indicate how important they felt science/chemistry outreach was for children they taught at different schooling levels. The pilot data indicated that there is a more varied range of importance expressed at primary level compared to secondary level. There was a 20% difference between participants' views who felt that science was 'quite a lot' or 'a great deal' of importance at secondary level or above compared to the importance at primary school level. When further exploring the data, 40% of the participants indicated that science outreach work importance was 'quite a lot' important at primary school level and over half (67%) of this same population felt that these programmes were 'a great deal' important at secondary level. This small sample indicates that teachers perceive science/chemistry outreach work to be more important at secondary level compared to primary.

Discussion

The pilot data provided a focal point for the main collection process. The following discussion allowed the researcher to link findings from the data to themes within literature, this increased confidence regarding the design of the original questionnaire and its objectives.

When considering the perceived importance of science outreach activities, Wilson and Chizeck (2000) noted that outreach activities are more frequently provided for middle school and high school students. These findings matched the pilot data as teachers in this sample perceived outreach to be more important at secondary school compared to its importance at primary school. This could possibly account for more programmes being provided in the secondary age range or due to the limited participants (secondary school teachers only) present in this sample. Thus, when the notion of 'age' will be further considered moving forwards as Wilson and Chizeck (2000) describe how the curiosity of the child should be nurtured at the earliest age possible. Maltese and Tai (2010) exemplify this statement as they find that often those who become scientists decide prior to attending high school. Therefore, the age range to which science outreach activities are offered to, is the first important theme to consider from the pilot data.

All participants in the pilot sample indicated that they felt science/chemistry outreach programmes are important for pupil premium students. In addition to this, the sample all agreed or strongly agreed that these initiatives also provide opportunities for pupils to experience opportunities they may otherwise not have had. Therefore, it could be that some outreach opportunities provide activities for pupils from a lower socioeconomic status (SES) to help them visualise belonging to a scientific community. Literature indicates that home may be an inhibiting factor in choosing science due to several reasons, such as the lack of a 'role-model', limited career advice or support from parents in that particular field (Fleer and Rillero, 2008; Gorard, 2008; Gorard and See, 2009).

Another discussion point links to how science/chemistry outreach activities may be perceived to be more important for girls. Whilst this is not the principle theme of the study (to compare gender) there is significant literature which highlights that young women may not choose to study science as it may challenge their feminine identity, especially when it comes to the physical sciences (Mendick, 2006). It is to be considered that outreach programmes may assist with 'diminishing this difference' (narrowing the gap) as Mujtaba and Reiss (2013) comment that girls feel like they receive less encouragement, compared to their male peers, in their physics studies. Marchand and Taasoobshirazi (2013) find that concerns regarding the lack of girls choosing to study physics could be due to the individual teacher and the teaching of the subject itself. Although these studies outline concerns specific to physics, Deemer et al (2014) describe how the gender gap is also visible in other disciples in science such as chemistry. Therefore, it is to be considered as to how outreach programmes may have the potential to provide a more relatable role models which could inspire and engage this underrepresented demographic within the field of physical sciences. The larger set of data will elicit if this is a general viewpoint of a larger sample of teachers or if this is just noted by a small number of secondary participants.

The two questions in the survey, which used thematic analysis, drew on themes determined by the literature. Question six initially only had the six original themes derived from the literature, however from the participants responses to this question, two new themes emerged surrounding how these programmes could assist with learning in the classroom and assisting learning in the curriculum. Many participants also commented on the delivery of the programme itself, such as time and cost of being involved in outreach activities. These two emergent themes also presented themselves in the literature reviewed as Shanahan et al (2011) discusses cost of the programmes and Glover, Harrison and Shallcross (2016) describe one of the reasons teachers chose to engage with Britsol ChemLabS (as a chemistry outreach programme) was to assist with pupil's learning. The responses regarding the participants' thoughts on what was science/ chemistry outreach work suggested they felt it involved external partners such as someone delivering an event at the school, or a trip to an organisation. However, towards the end of the questionnaire in the final open response question there is a wider view of what outreach activities are emerging. Therefore, the collection of further data to be analysed thematically was an important process to create further confidence in the themes generated and to deliver new emergent themes.

APPENDIX O: SPSS WORKED EXAMPLES REGARDING THE IMPORTANCE OF SCIENCE OUTREACH AT DIFFERENT EDUCATIONS LEVELS

Differences in school levels

Frequency Table

How important do you think science outreach work at primary school level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	1	1.9	2.0	2.0
	Very little	2	3.8	3.9	5.9
	A little	12	23.1	23.5	29.4
	Quite a lot	23	44.2	45.1	74.5
	A great deal	13	25.0	25.5	100.0
	Total	51	98.1	100.0	
Missing	99	1	1.9		
Total		52	100.0		

How important do you consider chemistry outreach work to be at sixth form/college level?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A little	5	9.6	9.6	9.6
	Quite a lot	13	25.0	25.0	34.6
	A great deal	34	65.4	65.4	100.0
	Total	52	100.0	100.0	

Descriptive Statistics

Schooling level		N	Minimum	Maximum	Mean	Std. Deviation
Primary school	How important do you think science outreach work at primary school level	16	3	5	3.81	.655
	Valid N (listwise)	16				

Secondary School	How important do you think science outreach work at primary school level	10	1	5	3.60	1.350
	Valid N (listwise)	10				
Secondary school with 6th form college	How important do you think science outreach work at primary school level	22	3	5	4.14	.710
	Valid N (listwise)	22				
All through school (3-16 or 18 years old)	How important do you think science outreach work at primary school level	1	5	5	5.00	.
	Valid N (listwise)	1				
6th form centre/college	How important do you think science outreach work at primary school level	2	2	3	2.50	.707
	Valid N (listwise)	2				

Kruskal-Wallis Test

Ranks

	Schooling level	N	Mean Rank
How important do you consider science/chemistry outreach work to be at secondary school level?	Primary school	16	23.69
	Secondary School	10	24.50
	Secondary school with 6th form college	23	26.13
	Total	49	

Test Statistics[a,b]

	How important do you consider science/chemistry outreach work to be at secondary school level?

Chi-Square	.362
df	2
Asymp. Sig.	.835

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
How important do you consider chemistry outreach work to be at sixth form/college level?	52	4.56	.669	3	5
Schooling level	52	2.98	1.462	1	6

Mann-Whitney Test

Ranks

	Schooling level	N	Mean Rank	Sum of Ranks
How important do you consider chemistry outreach work to be at sixth form/college level?	Primary school	16	18.69	299.00
	Secondary school with 6th form college	23	20.91	481.00
	Total	39		

	How important do you consider chemistry outreach work to be at sixth form/college level?
Mann-Whitney U	163.000
Wilcoxon W	299.000
Z	-.705
Asymp. Sig. (2-tailed)	.481
Exact Sig. [2*(1-tailed Sig.)]	.563[b]

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
How important do you think science outreach work at primary school level	51	3.88	.909	1	5
Schooling level	52	2.98	1.462	1	6

Mann-Whitney Test

Ranks

	Schooling level	N	Mean Rank	Sum of Ranks
How important do you think science outreach work at primary school level	Primary school	16	16.78	268.50
	Secondary school with 6th form college	22	21.48	472.50
	Total	38		

Test Statistics

	How important do you think science outreach work at primary school level
Mann-Whitney U	132.500
Wilcoxon W	268.500
Z	-1.413
Asymp. Sig. (2-tailed)	.158
Exact Sig. [2*(1-tailed Sig.)]	.201[b]

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
How important do you consider science/chemistry outreach work to be at secondary school level?	52	4.40	.748	3	5
School level primary or not	52	1.6923	.46604	1.00	2.00

Mann-Whitney Test

Ranks

	School level primary or not	N	Mean Rank	Sum of Ranks
	Primary	16	24.84	397.50

How important do you consider science/chemistry outreach work to be at secondary school level?	Sceondary and above	36	27.24	980.50
	Total	52		

Test Statistics[a]

	How important do you consider science/chemistry outreach work to be at secondary school level?
Mann-Whitney U	261.500
Wilcoxon W	397.500
Z	-.588
Asymp. Sig. (2-tailed)	.557

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
How important do you consider chemistry outreach work to be at sixth form/college level?	52	4.56	.669	3	5
School level primary or not	52	1.6923	.46604	1.00	2.00

Mann-Whitney Test

Ranks

	School level primary or not	N	Mean Rank	Sum of Ranks
How important do you consider chemistry outreach work to be at sixth form/college level?	Primary	16	24.09	385.50
	Sceondary and above	36	27.57	992.50
	Total	52		

Test Statistics[a]

	How important do you consider chemistry outreach work to be at sixth form/college level?
Mann-Whitney U	249.500
Wilcoxon W	385.500
Z	-.910
Asymp. Sig. (2-tailed)	.363

a. Grouping Variable: School level primary or not

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
How important do you think science outreach work at primary school level	51	1	5	3.88	.909
How important do you consider science/chemistry outreach work to be at secondary school level?	52	3	5	4.40	.748
How important do you consider chemistry outreach work to be at sixth form/college level?	52	3	5	4.56	.669
Valid N (listwise)	51				

Friedman Test

Ranks

	Mean Rank
How important do you think science outreach work at primary school level	1.57
How important do you consider science/chemistry outreach work to be at secondary school level?	2.15
How important do you consider chemistry outreach work to be at sixth form/college level?	2.28

Test Statistics[a]

N	51
Chi-Square	27.045
df	2
Asymp. Sig.	.000

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
How important do you consider science/chemistry outreach work to be at secondary school level? - How important do	Negative Ranks	4[a]	13.00	52.00
	Positive Ranks	26[b]	15.88	413.00
	Ties	21[c]		

you think science outreach work at primary school level	Total	51		
How important do you consider chemistry outreach work to be at sixth form/college level? - How important do you think science outreach work at primary school level	Negative Ranks	4[d]	10.00	40.00
	Positive Ranks	26[e]	16.35	425.00
	Ties	21[f]		
	Total	51		
How important do you consider chemistry outreach work to be at sixth form/college level? - How important do you consider science/chemistry outreach work to be at secondary school level?	Negative Ranks	5[g]	8.50	42.50
	Positive Ranks	12[h]	9.21	110.50
	Ties	35[i]		
	Total	52		

Test Statistics

	How important do you consider science/chemistry outreach work to be at secondary school level? - How important do you think science outreach work at primary school level	How important do you consider chemistry outreach work to be at sixth form/college level? - How important do you think science outreach work at primary school level	How important do you consider chemistry outreach work to be at sixth form/college level? - How important do you consider science/chemistry outreach work to be at secondary school level?
Z	-3.999[b]	-4.098[b]	-1.789[b]
Asymp. Sig. (2-tailed)	.000	.000	.074

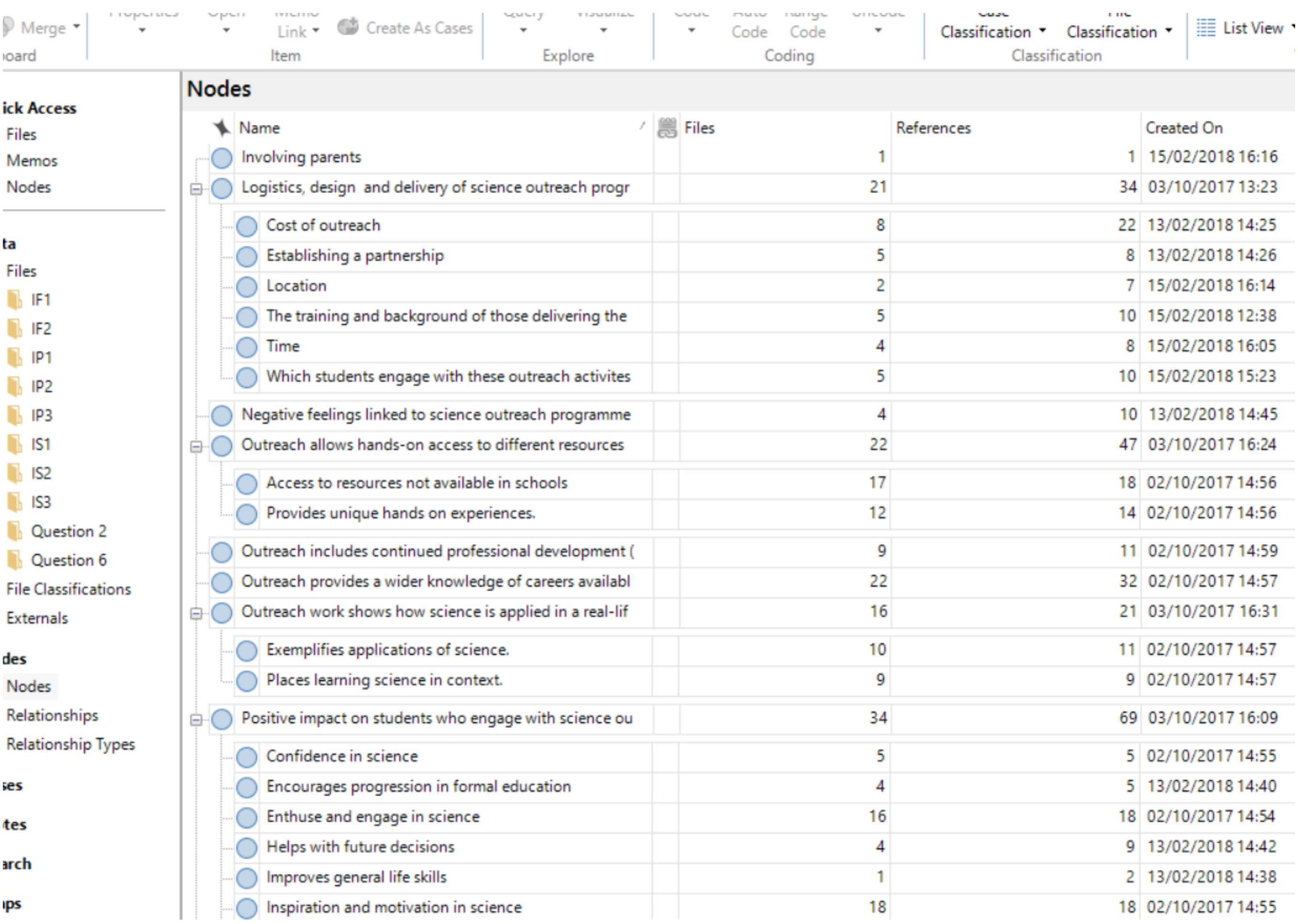
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of How important do you think science outreach work at primary school level, How important do you consider science/chemistry outreach work to be at secondary school level? and How important do you consider chemistry outreach work to be at sixth form/college level? are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

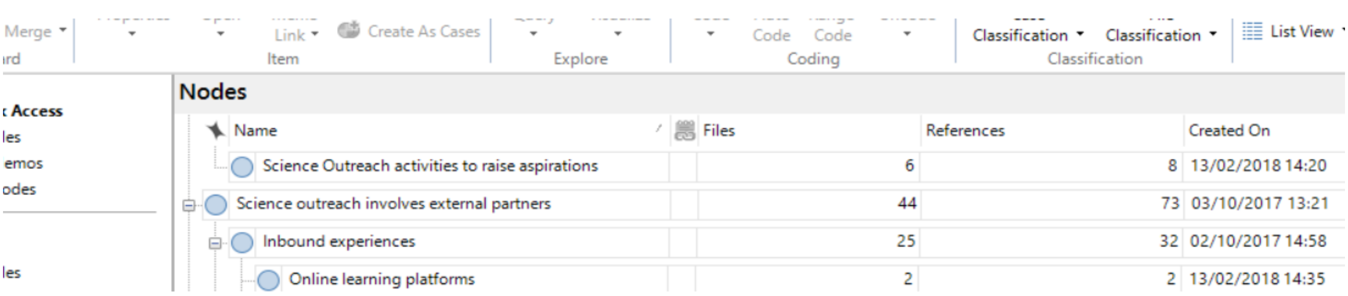
Asymptotic significances are displayed. The significance level is .05.

APPENDIX P: NVIVO STAGE 1 AND 2 EXAMPLES OF WORKING

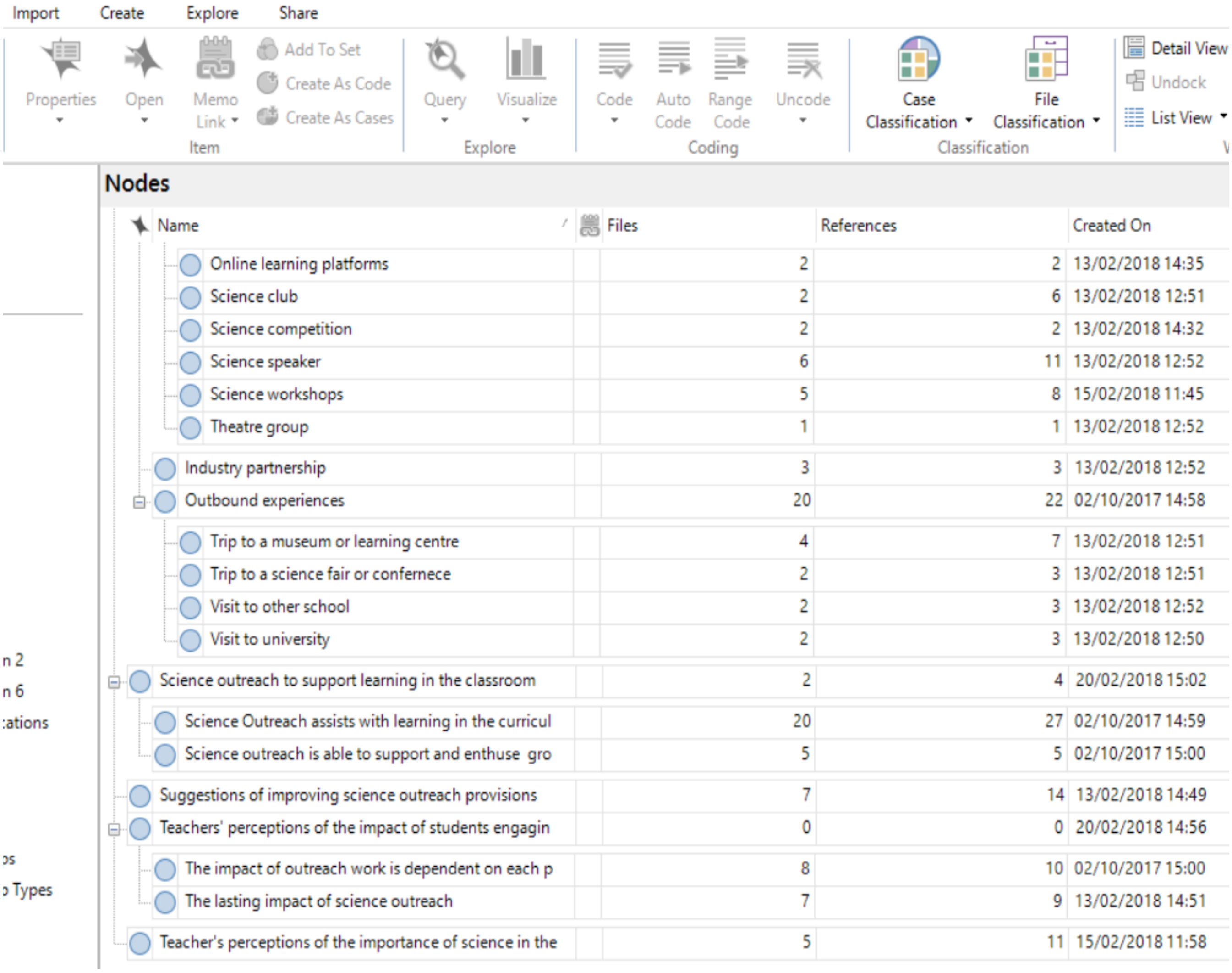
Open codes



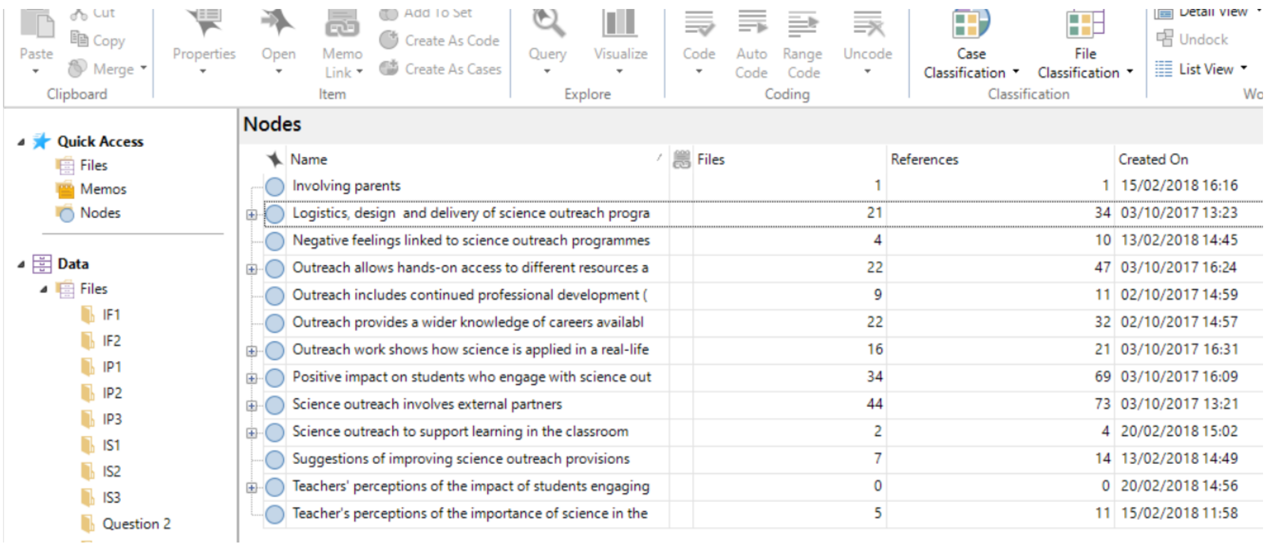
Name	Files	References	Created On
Involving parents	1	1	15/02/2018 16:16
Logistics, design and delivery of science outreach progr	21	34	03/10/2017 13:23
Cost of outreach	8	22	13/02/2018 14:25
Establishing a partnership	5	8	13/02/2018 14:26
Location	2	7	15/02/2018 16:14
The training and background of those delivering the	5	10	15/02/2018 12:38
Time	4	8	15/02/2018 16:05
Which students engage with these outreach activites	5	10	15/02/2018 15:23
Negative feelings linked to science outreach programme	4	10	13/02/2018 14:45
Outreach allows hands-on access to different resources	22	47	03/10/2017 16:24
Access to resources not available in schools	17	18	02/10/2017 14:56
Provides unique hands on experiences.	12	14	02/10/2017 14:56
Outreach includes continued professional development (	9	11	02/10/2017 14:59
Outreach provides a wider knowledge of careers availabl	22	32	02/10/2017 14:57
Outreach work shows how science is applied in a real-lif	16	21	03/10/2017 16:31
Exemplifies applications of science.	10	11	02/10/2017 14:57
Places learning science in context.	9	9	02/10/2017 14:57
Positive impact on students who engage with science ou	34	69	03/10/2017 16:09
Confidence in science	5	5	02/10/2017 14:55
Encourages progression in formal education	4	5	13/02/2018 14:40
Enthuse and engage in science	16	18	02/10/2017 14:54
Helps with future decisions	4	9	13/02/2018 14:42
Improves general life skills	1	2	13/02/2018 14:38
Inspiration and motivation in science	18	18	02/10/2017 14:55



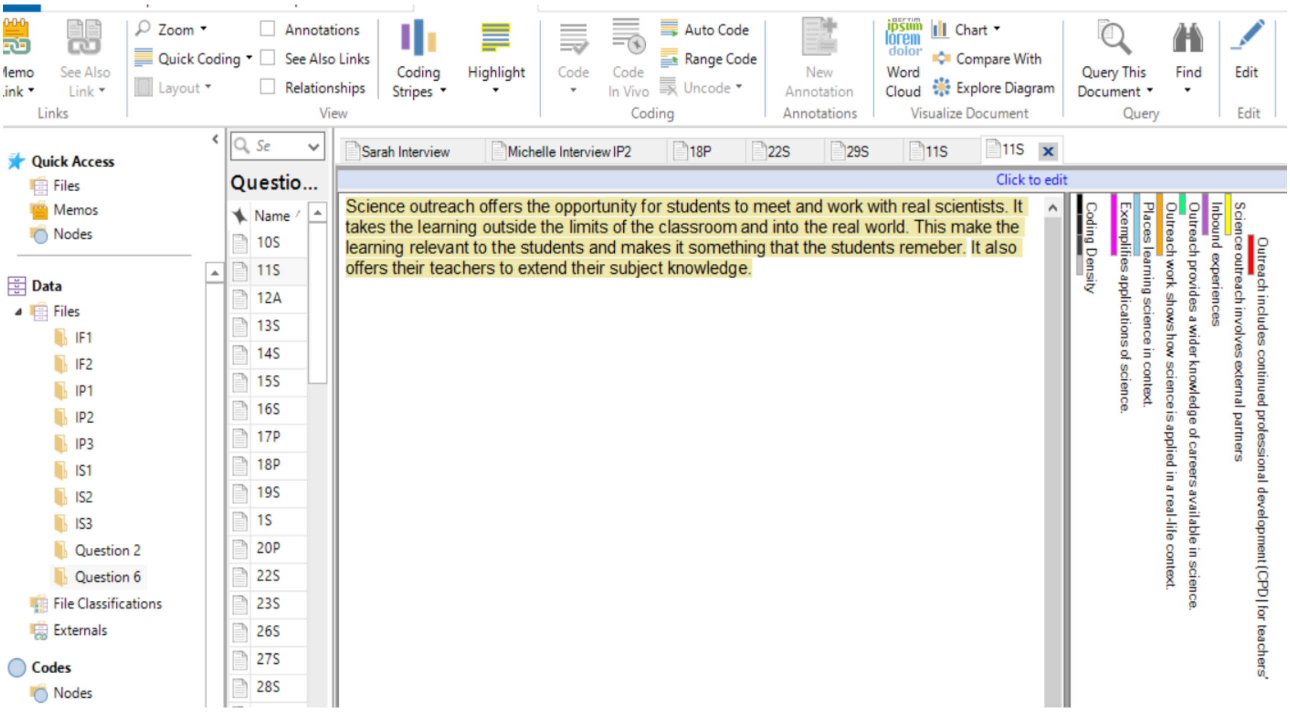
Name	Files	References	Created On
Science Outreach activities to raise aspirations	6	8	13/02/2018 14:20
Science outreach involves external partners	44	73	03/10/2017 13:21
Inbound experiences	25	32	02/10/2017 14:58
Online learning platforms	2	2	13/02/2018 14:35



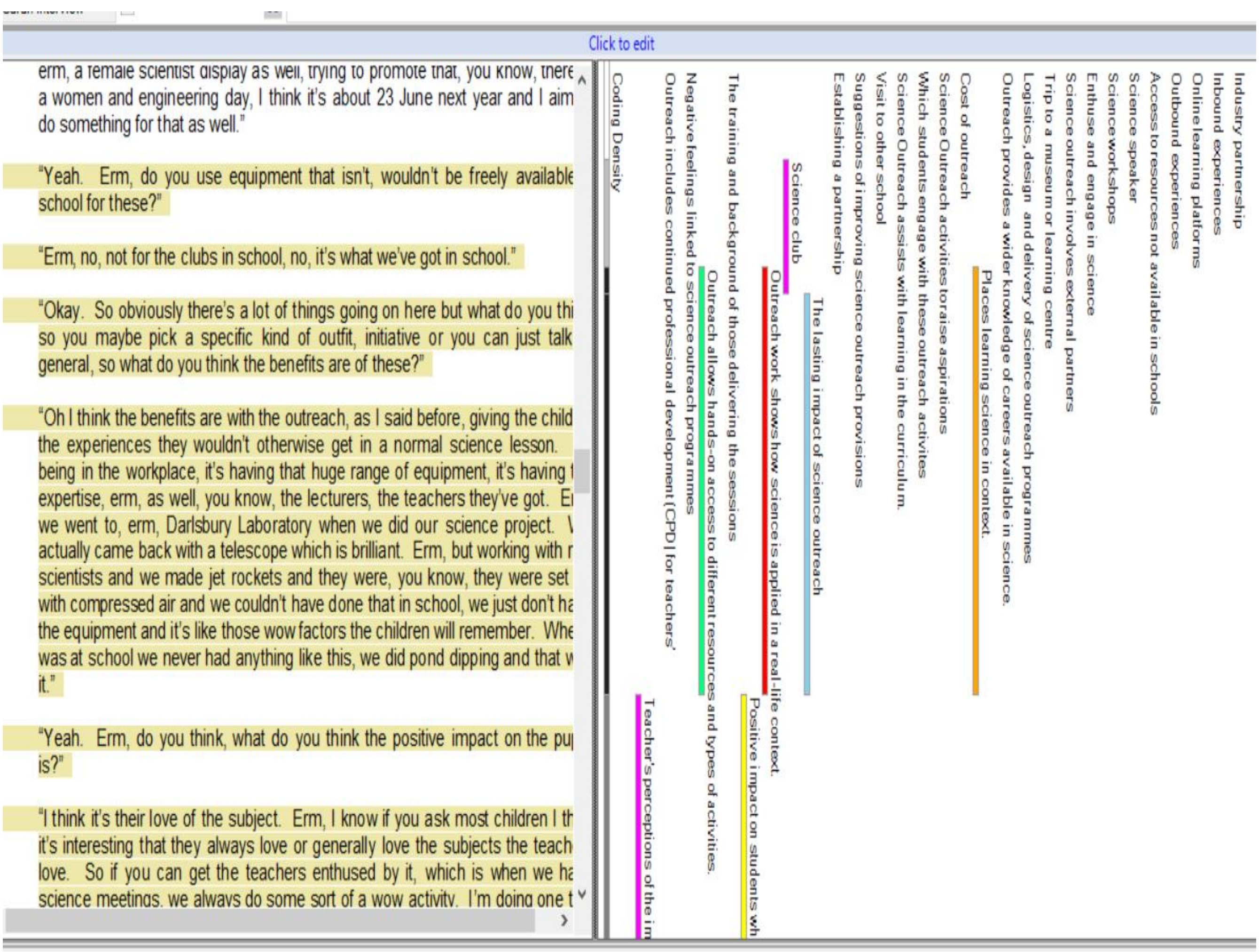
Refined themes



Example of coding of open questions



Example of coding a section of an interview transcript


Click to edit
erm, a female scientist display as well, trying to promote that, you know, there
a women and engineering day, I think it's about 23 June next year and I aim
do something for that as well."
"Yeah. Erm, do you use equipment that isn't, wouldn't be freely available
school for these?"
"Erm, no, not for the clubs in school, no, it's what we've got in school."
"Okay. So obviously there's a lot of things going on here but what do you thi
so you maybe pick a specific kind of outfit, initiative or you can just talk
general, so what do you think the benefits are of these?"
"Oh I think the benefits are with the outreach, as I said before, giving the child
the experiences they wouldn't otherwise get in a normal science lesson.
being in the workplace, it's having that huge range of equipment, it's having
expertise, erm, as well, you know, the lecturers, the teachers they've got. E
we went to, erm, Darlsbury Laboratory when we did our science project.
actually came back with a telescope which is brilliant. Erm, but working with
scientists and we made jet rockets and they were, you know, they were set
with compressed air and we couldn't have done that in school, we just don't ha
the equipment and it's like those wow factors the children will remember. Whe
was at school we never had anything like this, we did pond dipping and that w
it."
"Yeah. Erm, do you think, what do you think the positive impact on the pu
is?"
"I think it's their love of the subject. Erm, I know if you ask most children I th
it's interesting that they always love or generally love the subjects the teach
love. So if you can get the teachers enthused by it, which is when we ha
science meetings, we always do some sort of a wow activity. I'm doing one t
Industry partnership
Inbound experiences
Online learning platforms
Outbound experiences
Access to resources not available in schools
Science speaker
Science workshops
Enthuse and engage in science
Science outreach involves external partners
Trip to a museum or learning centre
Logistics, design and delivery of science outreach programmes
Outreach provides a wider knowledge of careers available in science.
Places learning science in context.
Cost of outreach
Science Outreach activities to raise aspirations
Which students engage with these outreach activites
Science Outreach assists with learning in the curriculum.
Visit to other school
Suggestions of improving science outreach provisions
Establishing a partnership
The lasting impact of science outreach
Science club
Outreach work shows how science is applied in a real-life context.
Positive impact on students wh
The training and background of those delivering the sessions
Outreach allows hands-on access to different resources and types of activities.
Negative feelings linked to science outreach programmes
Outreach includes continued professional development (CPD) for teachers'
Teacher's perceptions of the im
Coding Density

APPENDIX Q: REFINEMENT OF CODES DURING THE GT PROCESS

Changing minds about the future Mindset The nature of science Inspire Promote science	Change minds, Expectations, Raise self-esteem, Can do it, Raise aspirations, Provides potential, Changes views and perceptions, Remove from comfort zone, Further engage, Future engagement with science, Careers, Future choices, Not just about university route, Possible future choices, Careers and futures, Influence choices, Range of careers for a range of abilities, Real life context, Careers, Links to real life-use parents, Insights into the future, Real life context, Changes minds about science, Real life, Gives learning a context, New perspectives, Relevant, Changing perceptions of what the subject science is Careers and opportunities, raise aspirations in local environment, focus on role models from a younger age, people like them, widen understanding of what science is, making it relatable, ideas that most jobs contain some science. Bring science alive, highlight careers from a younger ages, something to aspire to, broadens horizons, promote science for all, broaden understanding of what science is, remove stereotypes, change mindsets.
Positives New experience Amplifies feelings towards science Learning (adds value) Raises science profile Positive impact to the design of the programme	Engage learners, Positive thoughts, Increase enjoyment, enjoyment, Talk about event after, Competition with other schools, Increases confidence, A positive new experience, Provides opportunities, Opportunities for new interactions, Motivates students, Challenges, Skills development, Opportunities, Benefit of long term interactions, New skills developed outside of normal lessons, Soft skills, See impact, Social skills, New experiences not get otherwise, Memorable, Raises science profile, Pupils enjoy trips-want more in other subjects, Problem solving, Interactive, New experiences, Older pupils inspire the younger ones, New resources, Engagement, Enjoyments, Raises profile of science, Learn more, Remember more, Experiences you wouldn't get at home, Encourages working together, Develop soft skills, Do take something from it (though not what you expect), Memorable, Often remember the experiments Role model-the idea of someone new, establishing longer relationships, using unique equipment, raising aspirations, making links, raises profile of scientists, gets the kids talking, bridge the gap, problems with school system that maybe 'fixed' by outreach eg. Including work experience. Support learners, some high quality experience of these programmes, access to new spaces and materials, light bulb moments, children want to be involved, hands-on, places science into real-life, could improve school-home relationship.
Negatives/concerns	Constraints of the curriculum, Changes opinions but not always for the better, Comparison with other schools, Enjoyment doesn't last long, Don't remember, Can be stressful for the pupils, Exam

"Lack of time/pressures"

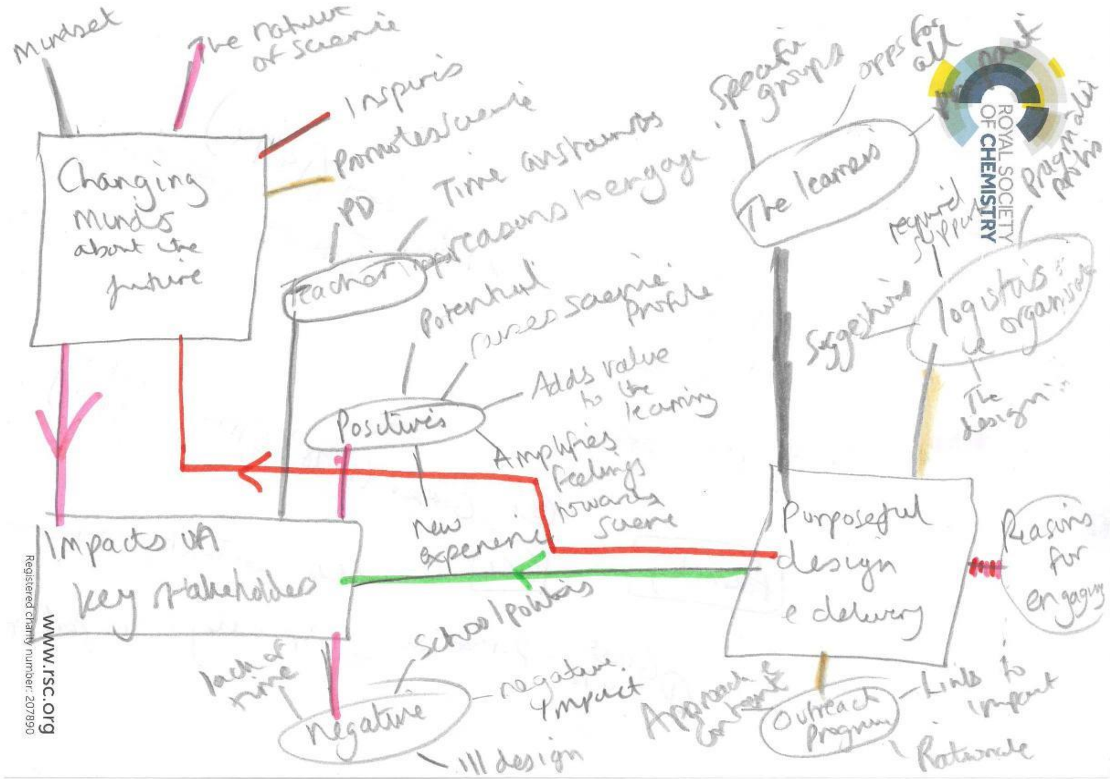
	pressure, nerves, Curriculum pressure, Exam pressure, Less science since not SATs at KS2, Hard for parents to be interested Some students may demonstrate 'bad' attitudes, low aspirations so less engagement, aftermath of (exciting) outreach causes dis-engagement in lessons, us V them (teachers V outreach providers), fun v exam, never comes without a price, exam pressures/time cost, takes away from exam prep, not all experiences have a positive effect, not always remember the learning, not always memorable for the right reasons, the outreach may have its own agenda, Hit and miss experiences, systematic changes in schools impact on parental engagement, the type of activity v what regularly happens when teaching science. Opportunity to engage with outreach events may stop all of a sudden, cost, mis-match in opportunity, frequency is less, time constraints to curriculum.
Teacher impact	Raise teacher awareness, Provides information, Teachers aware of changes in science, New information for teachers, Inform teachers, Teachers see pupils learning needs, Changing times, Teachers take away what they need to know, Teacher's time, Extra admin, Above and beyond, Teacher feeling of helping is the rewards, Give it a go but is aware of time, Follow up activities for the teacher to do (report), More time for teachers, Teachers enjoy activities, Give up 'free' time if weekend away, Share the load, Build upon teacher-pupil relationships, Builds trust and engagement out of school, Share knowledge, Networking, Happens through random emails, Partnerships, Connect with high schools, Meet other teachers, Raise teacher awareness of educational levels, Extra responsibility, Have to be willing to do it, More admin For the teachers not just the students, working with the lab technician, teachers don't see all events as a success, schools struggle with parental engagement. Support teachers, CPD, teachers can use the resources in their own classroom, how to use people as a resources too, teachers learn how to use the equipment, tap into expertise, free CPD, use of STEM ambassadors, share resources, networking, ideas to improve own teaching, somethings more simple that anticipated, issues with teacher specialism, opportunities to collaborate, outreach important fopr teachers too.
Links to formal learning	Outside context, Make it real, Bringing in 'real' people, Shows potential of science, gives learning a context, Still need to do more work, Reality Check, Can see the impact, Trips V lessons-mismatch, Light bulb moment, Different structures, Skill development, Pupils more relaxed so learn more, Beyond the curriculum, Subject enrichment, Introduce the topic, Curriculum topics, Expect to expand the topic, Outreach is part of the curriculum, Integrated,

	Experiences contextualise science and make it real, outreach can extend the limitations of school science, boost practical skills. Becomes more exciting, different to the norm, contextualise ideas, can link to local environment, important links to the NC, links to a topic, promote scientific vocabulary.
Logistics and organisation of events	Logistics of organising, Supportive head teacher, Schools often want measurable feedback, 'exam' cultures, Head support is crucial, Reluctant to organise in first place (all year groups), Cost, Time can be a barrier, Time is precious, Not recognised as part of teaching role, Extra, Not in job description, Some schools have it as a paid extra role, Need supportive head, Disparity in schools, Differences between private v public, How often, Assist with costs, Don't happen often, Take place in and out of school, Someone comes in, Cost, Supportive head, Proximity and location, Locations, Time-teacher workload, Lots of organise, Logistics of getting out, Costs to go, Longitudinal events are more effective, Better to support the curriculum, links to industry, links to careers, quite ad hoc, Dependent on what is offered to the school (on how much they engage), events that cater for all students, important to have a positive relationship between the learners and facilitators, provide more work experience, health and safety restrictions, teachers have different experiences of these programmes, cost/money, longitudinal involvement takes more time, providers need knowledge of the students, need to differentiate, design important, value engaging parents, need an objective before the event, using new spaces, something they can take home with them, school politics, turn out at voluntary events, Providers can be high schools, should contextualise learning, have a bit of fun/humour, have something for the schools to take-away, event contains a variety, needs to be funded, more accessible, doesn't happen very often, leaving school can make it more memorable, links with the STEM agenda, include parents, pragmatics of parent involvement is difficult, communication difficult at times.
Reasons for engaging with Science outreach	Rewards learning, Treat, Rewards, Give new activities to use (ready made), Integrate skills, New experience, Experiences they wouldn't get at home, More memorable, Partnership between facilitators and schools, boost practical skills. Tap into expertise of others, take-away something, novel experiences, enthuse and engage.
The learners themselves	Diversity of experiences, Not the same for all pupils, Specific groups of learners, Attitudes towards trips, Pupils refuse to go, But have a good day in the end, High ability might have a positive experience, Money for pp pupils, High ability might not be enthused, G&T, PP, Dependent on the individual, Some groups of students more reluctant, Don't get the experiences at home, Nervous, pp students

	get advice about uni, Reluctance, Fixed mind-set, PP, Lot of children not pp have the same issues, Remember from an early age Events that cater for all abilities, opens their eyes, no-one in family may have been to university, enthuse kids already enthused (top set), accessible for all, raising aspirations very important for lower SES pupils. Random who gets to experience these events, have different exposure to these different events, impacts upon all learners, its for all children, spend more quality time with teachers/parents.
The outreach programme itself	Different stakeholders, Appeals to all abilities, Well planned outreach, Needs good planning, Develop skills but not in terms of knowledge, Easier to do in school, Not as big impact when done is school, More impact outbound events, More than just a 'trip out', Is bigger than just a science trip, Lots of schools involved in the events, Provides missed opportunities, Unaware of what science outreach is, Wow Factor, Link to the curriculum subjects, Mixed with a play (theatre), Trips, Engaging with science events, Bring new resources into school, Approached by a high school, Supporting STEM week, Transition, Using new equipment, Parental engagement, Hands-on, Doing it for themselves, Extra/outside the classroom, Go where they don't with parents, Doing not learning about, Who and why outreach is delivered, recruitment event, making it relatable, hands-on, unique experience, can foster connections, better when targeted, important of the facilitator themselves, needs to be well designed, know target audience, reachability, know the demographics, less impact as a stand alone event, utilise parents to have a more lasting impact, enhance links between school and home, communicate ideas about science at home. Could assist with transition, cover popular topics, promote scientific literacy, active, longer the event-the more memorable, outline careers than don't just need uni, get parents onboard.

Fostering learning and perceptions in science	Impact on key stakeholders	Purposeful delivery and design
• Changing minds about the future • Links to formal learning	• Positives • Negatives/concerns • Teacher impact	• The learners themselves • The outreach programme itself • Logistics and organisation of the events • Reasons for engaging

APPENDIX R: GT DIAGRAMMING TO ASSIST WITH CODES AND THEORY BUILDING (ROUGH WORKINGS)



Is a characteristic of

Is used for

Is a way to

Is a part of

Is a result

Is a part of

Spradley (1974)
Semantic relationships

Glaser (1978) Strauss & Corbin (1990)

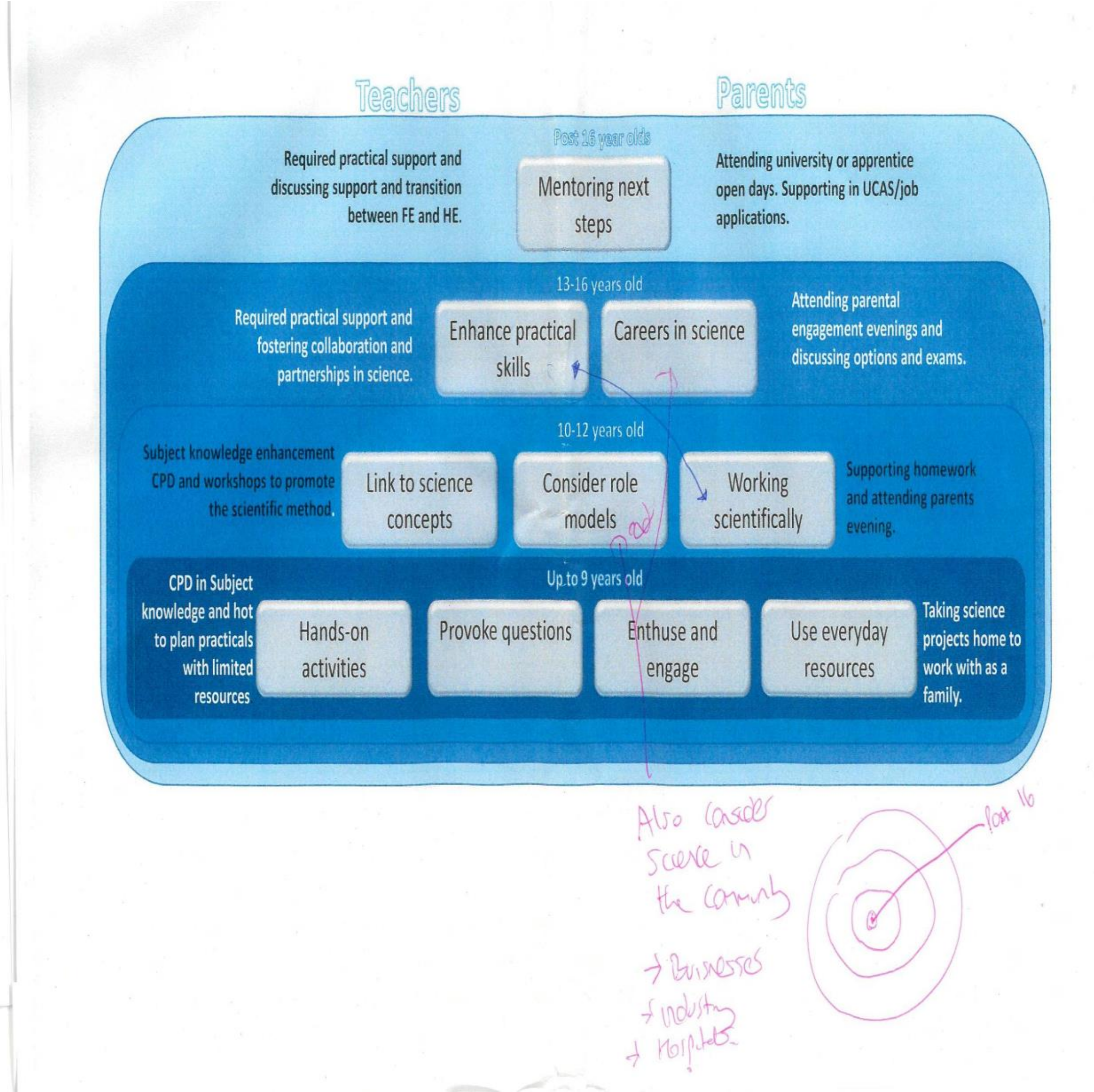
(2) Glaser (1978)

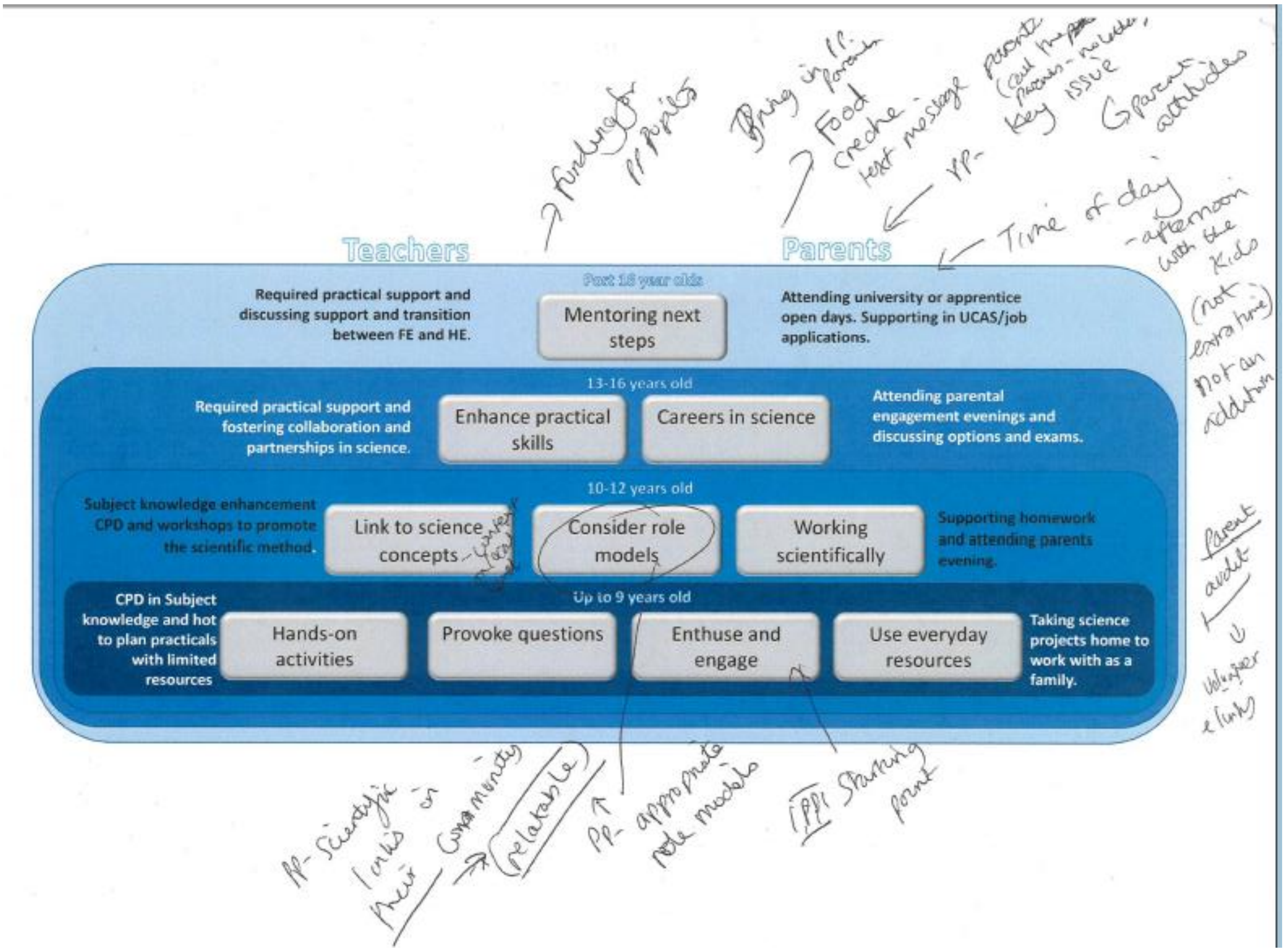
Family - 6Cs Causes, context, consequences

(1) Glaser 1978 - Dimension = Spradley's 'is part of'

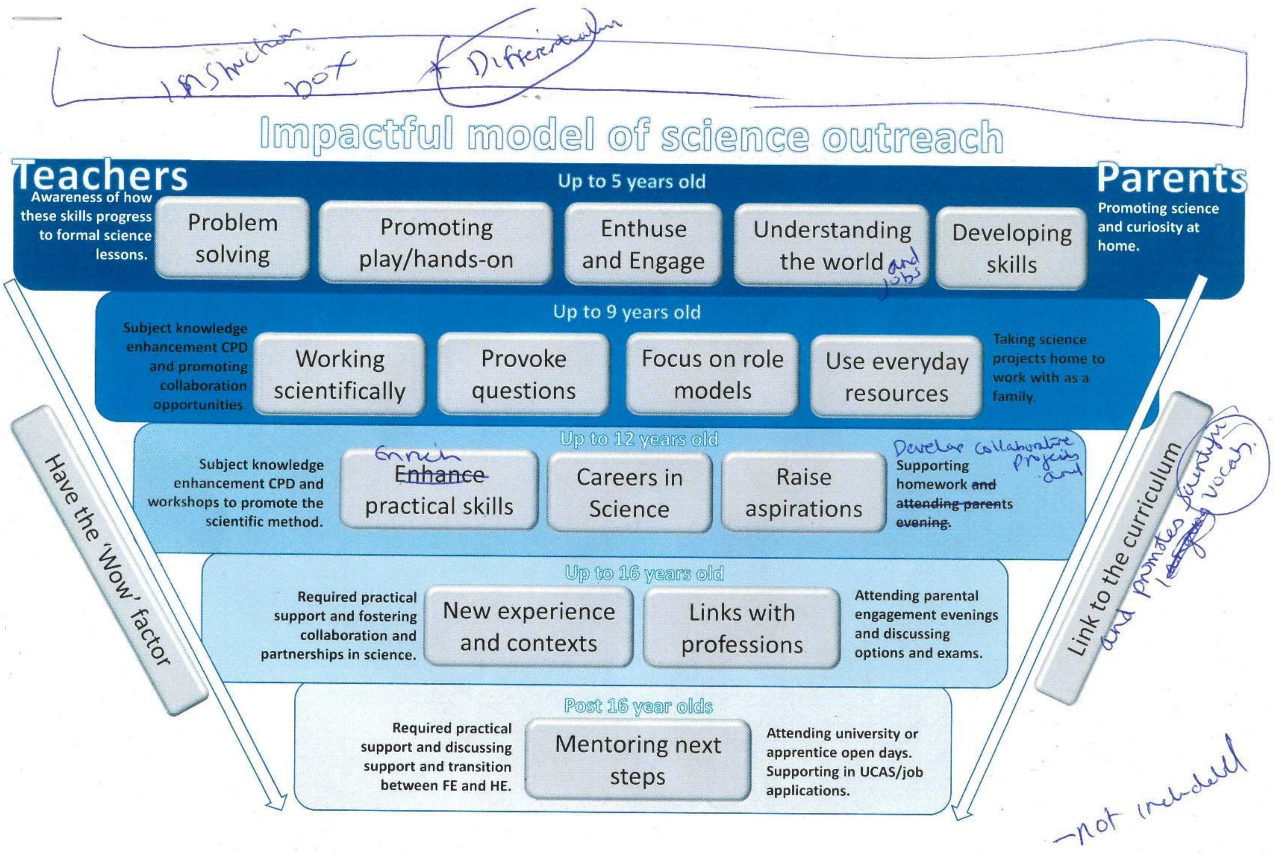
APPENDIX S: EXAMPLES OF ANNOTATIONS ON THE MODELS DURING THE FOCUS GROUPS

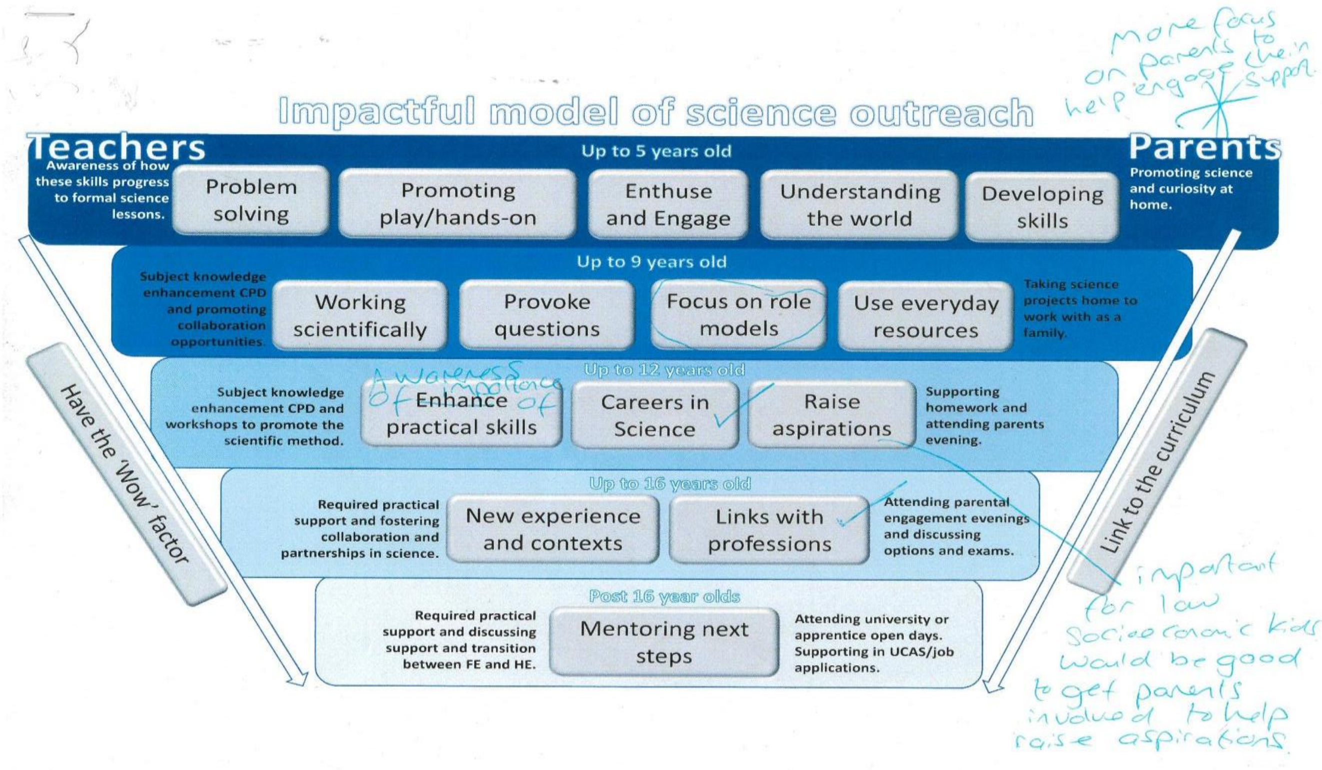
Wave 1




Teachers
Parents
Post 18 year olds
Required practical support and discussing support and transition between FE and HE.
Mentoring next steps
Attending university or apprentice open days. Supporting in UCAS/job applications.
13-16 years old
Required practical support and fostering collaboration and partnerships in science.
Enhance practical skills
Careers in science
Attending parental engagement evenings and discussing options and exams.
10-12 years old
Subject knowledge enhancement CPD and workshops to promote the scientific method.
Link to science concepts
Consider role models
Working scientifically
Supporting homework and attending parents evening.
Up to 9 years old
CPD in Subject knowledge and hot to plan practicals with limited resources
Hands-on activities
Provoke questions
Enthuse and engage
Use everyday resources
Taking science projects home to work with as a family.
Time of day
Food
creche

Wave 2


Impactful model of science outreach
Teachers
Parents
Up to 5 years old
Awareness of how these skills progress to formal science lessons.
Problem solving
Promoting play/hands-on
Enthuse and Engage
Understanding the world
Developing skills
Promoting science and curiosity at home.
Up to 9 years old
Subject knowledge enhancement CPD and promoting collaboration opportunities
Working scientifically
Provoke questions
Focus on role models
Use everyday resources
Taking science projects home to work with as a family.
Up to 12 years old
Subject knowledge enhancement CPD and workshops to promote the scientific method.
Enhance practical skills
Careers in Science
Raise aspirations
Supporting homework and attending parents evening.
Up to 16 years old
Required practical support and fostering collaboration and partnerships in science.
New experience and contexts
Links with professions
Attending parental engagement evenings and discussing options and exams.
Post 16 year olds
Required practical support and discussing support and transition between FE and HE.
Mentoring next steps
Attending university or apprentice open days. Supporting in UCAS/job applications.
Have the 'Wow' factor
Link to the curriculum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Required practical support and discussing support and transition between FE and HE.
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Have the 'Wow' factor
Link to the curriculum