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Emerging perspectives on the demonstration as a signature pedagogy in design and technology education

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Abstract This paper analyses the beliefs of teachers regarding the demonstration as a signature pedagogy in design and technology, where there is a limited body of literature outlining the theory and practice. The demonstration is multifaceted, and effective teachers adopt and adapt a range of skills and values to scaffold learning, including teacher modelling and explaining. The study explores the subjective beliefs of seven practicing teachers through Q Methodology; comparing and analysing the responses of the participants' subjective beliefs and values, using 62 statements relating to teacher modelling and explaining, developed and refined with teacher educators, and representing the concourse of opinions and perspectives. The sample is purposive, comprised of practicing teachers who are engaged with mentoring trainees in Initial Teacher Education. The findings will represent a snapshot of subjective values of practicing teachers, as part of a discourse on signature pedagogies in design and technology education.

Keywords Demonstration · Teacher modelling · Explaining · Pedagogy · Teaching methods · Q methodology · Design and technology

Introduction

The primary aim of this study is to analyse the subjective beliefs of teachers regarding the demonstration as a signature pedagogy in design and technology. A secondary, long-term, aim is to encourage dialogue in the design and technology community on effective pedagogies and contribute to the development of theoretical frameworks which inform classroom practice. The research question is: What do teachers of design and technology believe to be effective pedagogy when demonstrating skills and knowledge?

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Viewed from a pragmatic perspective, in formal learning “involving the use of the body and the handling of material”, the act of demonstration is an essential teaching method in practical disciplines (Petrina 2007; Dewey 1916, p. 178). This paper explores teacher of design and technology views about the demonstration. Despite the subject being formally recognised in the National Curriculum for England in the late 1990s (DfE 1995, 2013; QCA 2004, 2007; DfEE 1999; NCC 1990), almost three decades on, there is limited research and pedagogical literature to underpin practice in this area (McLain et al. 2015). Whilst this study focuses on the views of teachers in England, and the relative historical and cultural context, the nature of the discussion in this paper is relevant to creative, practical and technical subjects internationally; be they craft or technology based, emerging into or embedded as a design and technology based curriculum.

The demonstration is an important pedagogical method in other practical subjects, including science (Milne and Otieno 2007) and physical education (Mosston and Ashworth 2002). In design and technology, it builds on the traditions of apprenticeship and craft education of “demonstration, observation and constant practice” (Mason and Houghton in Sayers et al. 2002, p. 44). Petrina comments on the significance of demonstrations as “the single most effective method for technology teachers” (Petrina 2007, p. 1).

Central concepts and literature review

There is relatively limited range of literature on demonstration and teacher modelling in design and technology (McLain et al. 2013). This section will draw on explicit references both within and beyond the subject, and make links with wider learning theories.

By way of definition, this paper assumes that a demonstration is, primarily, a combination of teacher modelling (DfES 2004a) and explanation (DfES 2004b)—respectively, largely visual and auditory approaches—supported other pedagogical skills such as questioning (DfES 2004c); each of which do not define demonstration, in themselves, but together are pedagogical techniques employed by the teacher of design and technology when demonstrating. Demonstration focuses on knowledge transfer of technical processes and the practical application of knowledge—demonstrated by the teacher and replicated by the learner. The teacher, as an expert subject practitioner, or more knowledgeable other (Vygotsky 1978), makes conceptual and procedural knowledge (McCormick 1997) explicit in a meaningful context. Therefore, effective modelling and explanation facilitates the development of understanding of a process, including sequence, related knowledge and next steps.

> “**Modelling** is an active process, not merely the provision of an example. It involves the teacher as the ‘expert’, demonstrating how to do something and making explicit the thinking involved.” (DfES 2004a: 3; emphasis mine)

> “The purpose of **explaining** a process or procedure is to help pupils understand how things happen or work. The emphasis is on sequence and connectives such as first, next, then and finally are important.” (DfES 2004b: 3; emphasis mine)

Vygotsky’s (1978) theory of social constructivism and the zone of proximal development (ZPD) provide a useful lens for critiquing learning and pedagogy in the context of this study. Tappan comments on the mediating role of tools (physical and linguistic) in Vygotskian theory, and their ability to “shape human mental functioning” (1997: 78). Daniels et al. (2007) further elaborate on the Vygotsky’s notion of mastery and development of these mental functions involving the "creation of external technology" (p. 66). Vygotsky described the process of learning (internalisation) as internal reconstruction of an external activity, "incorporated into [a] system of behaviour" (1978: 56–57). The ZPD "is the distance between the actual developmental level… and the level of potential development… under adult guidance or in collaboration with more capable peers." (p. 86).

This has implications for how and when the teacher should demonstrate, as he suggest that the evaluation of mental development should be "the assistance of others, without demonstrations, and without leading questions" (p. 88). The implication being that a demonstration, whilst being a useful scaffold for learning, obfuscates the requirement to recall and apply learning. In other words, a cautionary note should be attached to the use of demonstration, considering appropriate timing and the need to consider the appropriateness of frontloaded, just-in-time or after-failure approaches. *Frontloaded* instruction relies on the learner's ability to translate observations from working to long-term memory (Brown et al. 2014: 46–66; Baddeley 2000), but provides a holistic demonstration of a process or skill, in its wider context. Whereas the *just-in-time* approach mediates this process for the learning by removing the necessity to encode complex information to long-term memory and reduces cognitive load (Martin 2016), but removes some of the necessity for the learner to think and make decision autonomously. An *after-failure* approach has a number of potential applications, including with the use of a discovery learning approach (Brunner 1961), which allows for exploration and trial and error, although in some contexts may have safety implications; and in a corrective context, where the teacher observes pupils' engagement with a task or process, diagnoses misconceptions or errors and intervenes as a 'more knowledgeable other'.

As noted by McLain et al. (2015), the demonstration encompasses teacher modelling and explaining, and includes the manipulation of *physical tools (*materials and making), to *virtual tools* (software, including computer-aided manufacture) and *cognitive tools* (design thinking and problem solving); reflecting Wartofsky's (1979) levels of artefact. In design and technology learners explore, create and evaluate (DfE 2015). The teaching of the physical, virtual and cognitive domains has similar features, as well as distinctive differences, concerning the learner, context, resources.

Petrina (2007) identifies that the primary aim of a demonstration is to "communicate and model" procedural knowledge of 'how to do something" and conceptual knowledge of "how to talk about [a] task" (p. 14); and involves demystification of equipment and procedures, explanation of expected outcomes and the application of knowledge. It is commonly accepted that much of human communication is *non-verbal*, mediated by symbols, signs and actions (Engeström 2009; Vygotsky 1978, cited in Tappan 1997; Wertsch 1985, 1991, cited in Tappan 1997). In neuroscience, the much debated notion of mirror neurons (*cf* Thomas 2012) has sought to explain the ability of primates to mimic through observation and perception. Petrina goes on to state that words in themselves are inadequate to explain technological principles and processes. In fact, this is the de facto rationale for the demonstration.

McLain et al. (2015) speculated that the fundamental and tacit nature of demonstration, as a pedagogical method, is socially assimilated through the act of observing and intuition within the community of practice (Wenger in Illieris 2009; Duguid 2008; McLain 2012; Lave and Wenger 1991), and that this may go some way to account for the limited research in the area. They go on to observe that the demonstration is a "multifaceted skill" (p. 269) combining a range of pedagogical techniques. Implicit is the notion that much teacher knowledge of demonstration, as a *signature pedagogy*, is engaged with at a subconscious or automatic level. Kahneman (2011) describes this as *System* 1, the subconscious aspect of the mind, which responds effortlessly and draws on prior experience and encoded memories or patterns, without the need to draw on the slower, conscious, *System* 2. Whilst the automatic nature of System 1 thinking is relatively quick and efficient, without the engagement of System 2, learning and the development of expertise is impaired and error (or biases) can affect practice.

In order to overcome the inherent weakness of operating solely on automatic thought and action, the practitioner adopts a reflexive interplay between the subconscious and conscious knowledge, challenging misconceptions and strengthening practice. Much has been written about the importance of reflective practice for professional development (*cf* Wood et al. 2009; Race 2007; McCormack 1997; Schön 1991; Luft 1982) and specifically for teachers (*cf* Banks et al. 2004; Jay and Johnson 2002; Brookfield 1995). Ericsson and Pool (2016) write about naïve, purposeful and deliberate practice. Purposeful practice differs from naïve practice in that it requires that the learner focus their full attention on the skill, immediate feedback and moving beyond the bounds of current knowledge or skill. Naïve practice, where the same set of skills is repeated over time with limited reflection and development, can result in more recently trained professionals performing better than seemingly more experience colleagues. Deliberate practice is described as taking purposeful practice further, enhanced by proven techniques developed by experts, with a mentor figure playing an important role, providing real-time feedback, alongside the self-reflection (internal feedback) of the practitioner. Therefore, the lack of research and documented proven techniques, in relation to teacher modelling, potentially inhibits the professional development of teachers of design and technology, and thus learners in the subject.

Visual processing, and interpretation, is sophisticated with the mind constructing and reconstructing what we see into something that we can understand. Individuals perceive and understand in different ways from differing perspectives (physical and cognitive), so the effective demonstrator should consider the important aspects of the activity that the observers need to see. Learning is a complex process, drawing on memory and sensual experience. Whilst focusing on specific ‘learning styles’ can be counterproductive (Sharp et al. 2008), lacking in research and mythologised (Kirschner 2017), the inclusion of variety of approaches that take into consideration the wider intelligences of learners (Brown et al. 2014; Sternberg 2011; Gardner 1983, 1993, 1995, 1999). Barlex and Carré add a situated and cultural dimension suggesting that learners “do not see things as they are, we see them as we are” (1985, p. 4). In other words, the learning experiences, be they assimilated or accommodated into memory, influence our perceptions.

When planning for learning, teachers make pedagogical choices which can be considered to be on an *expansive-restrictive continuum* (Fuller and Unwin 2003). In other words, the teacher, as a more knowledgeable other adapts content knowledge to be demonstrated to the learner, taking into consideration factors such as age, prior learning, expected learning outcomes. For example, when teaching a new concept or skill to a group of younger learners, the choice might be to adopt a more *restrictive* and teacher led approach, with questions being used to gauge *recall* and *understanding*. This restrictive approach will limit the range (and potentially the creativity) of outcomes, whereas a more expansive approach (where learner potentially make more choices) can result in a broader range of outcome, which might be less skilfully realised if the requisite skills have not already been developed.

Theoretical framework and research design

This Q Methodology (Brown 1980) study adopted pragmatism as the philosophical and conceptual framework, in the traditions of Dewey, Pierce and James (Watts and Stenner 2012, pp. 24–46). The research paradigm is ontologically relativist, recognising the subjective nature of realities for individuals, which are multiple (Guba 1981, p. 77, 1990, pp. 17–27). As a Q Methodology study, the focus is on the socially and culturally constructed, subjective beliefs and values of the participants in relation to the *object* of teaching and learning practice (Watts and Stenner 2012, p. 29). In this aspect the intentions of the Q Method are interpretive and qualitative, using Peirce's "abduction", where observation of facts are used "in pursuit of an explanation and new insight" (p. 39).

Q Methodology originates from psychology research and "focuses on subjective or first person viewpoints" (Watts and Stenner 2012, p. 4). As such it does not purport to generate or confirm generalizable concepts and principles. With its roots in pragmatism, it draws on inductive and abductive reasoning with the support of mathematical modelling (factor analysis) to explore qualitative data through quantitative methods. In Q Methodology the comparison focuses on the similarities and differences between the participants, rather than their responses as is common within tradition factor analysis. A series of statements, or Q Set, that represents the broad range of opinion or belief (concourse) potentially held by the population that the sample is being drawn from. The participants then undertake a Q Sort activity. This is typically a two stage process involving a pre-sort into three categories (essential, desirable and optional, in this study), followed by the main sort where the Q Set statements are sorted into a *forced-choice frequency distribution* (Fig. 1) ranging from most agree to most disagree (note: the statements in this study were not designed to generate disagreement, so the 'most disagree' is relative).

The initial Q-Set was developed through a focus group of six teachers of design and technology, working with initial teacher education trainees in the North West of England, and refined by McLain et al. (2015) within an online, predominantly UK-based, community of practice for design and technology teacher educators. The list was divided into 10 categories to aid the presentation and interpretation of the 62 statements (see "Appendix").

An online Q-Sort was completed by a sample of seven teachers (Table 1) from a range of backgrounds and design and technology specialist areas, with only Participant 1 having been part of the initial focus group (above). Five of the participants are currently involved with initial teacher training (ITT) with management responsibilities that involve working both within and outside of their place of employment; Participant 4 and 7 being recently qualified teachers.

The Q-Sort for this study was conducted using an online questionnaire tool, QSortWare (Pruneddu 2014), to enable wider participation across institutions. The population for the

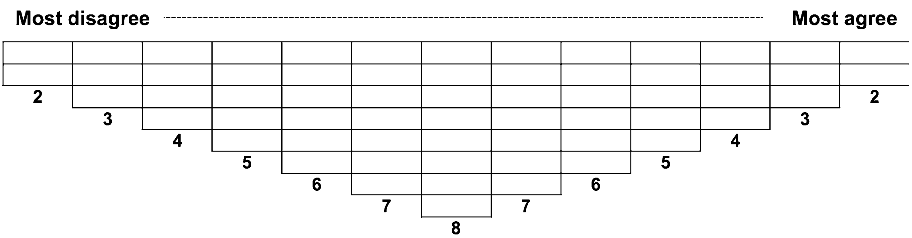


Fig. 1 Q Sort distribution

Table 1 Factor loadings, with X indicating defining sort (n = 7)

Q-Sorts	Specialist area	Gender	Loadings	
Participant 1	Electronic and control	Male	0.65	X
Participant 2	Graphic design	Female	0.58	X
Participant 3	Product design	Male	0.40	X
Participant 4	Product design	Male	0.38	X
Participant 5	Engineering	Male	0.03	
Participant 6	Fashion and textiles	Female	0.16	
Participant 7	Graphic design	Mail	0.64	X
Eigenvalues			1.51	
Variance			21%	

study was experienced teachers of design and technology engaged with the mentoring of ITE trainees and with links to members of the institutions that the research team represent; with the sample being purposive (Guba 1981). The factor analysis for data analysis was conducted using the PQMethod (Schmolck 2014) software.

Ethics, reliability and validity

This study was conducted with the informed consent of the participants and anonymity has been maintained for the individuals and their institutions. Limited personal information was gathered from participants. The problematic issues of researcher bias, validity and reliability (Lincoln et al. 2011) are addressed by adopting Guba's (1981) criteria for assessing trustworthiness. Guba describes the problems with imposing a scientific approach to testing the quality of naturalistic, or qualitative, research: proposing criteria of credibility, transferability, dependability and conformability (pp. 79–88). Credibility has been addressed through researcher-stakeholder engagement throughout the process of the development of the Q-Set with teachers, teacher educators and educational researchers; and presenting preliminary findings at conferences with peers in the field (McLain 2016; McLain et al. 2015). Transferability is sought by the researcher's aim to understand subjective views and avoid making generalised claims without reference to external and corroborative evidence. Dependability and confirmability of the findings will, ultimately, be tested through future studies, with larger samples using a variety of overlapping methods, and in this study are contextualised in the conceptual framework developed through the literature review.

Findings and interpretation

As an exploratory study into subjective beliefs and values, a small sample size does not pose a problem in Q Methodology, according to Watts and Stenner (2012). The findings are not being used to infer generalizable theoretical principles, rather to explore existing practice with the view to refine the 62 statements (see "Appendix") relating to teacher modelling and explaining within the subject. A future study with a larger sample would then be appropriate and more valid as a means to establish a recognised orthodoxy, with regard to demonstrations in design and technology. Further study is also required to develop and refine the Q-Set statements.

The initial comparison of participants' responses to the Q-Sort (Fig. 2), from the PQMethod Q methodology analysis software (Schmolck 2014), indicate the superficial correlations between the participants ranging from 44 (Participants 1 and 2) to −1 (Participants 1 and 5), with Participant 5 showing the lowest correlation to the overall. This reinforces the perception that the nature of teaching and learning is complex, with no 'one size fits all' approach. The responses of both Participant 5 and 6 demonstrated weaker correlations with the other participants in the sample. Due to the sample size, inferences in relation to the participants' specialism or gender have not been drawn.

PQMethod was used to extract factors (Table 1) and reduce the data, with the Eigenvalues (EV), or Kaiser-Guttmann criterion, above 1.00 used to indicate the statistical strength (Watts and Stenner 2012). Watts and Stenner advise that Q Methodology researcher try to extract one factor for every 6–8 participants (p. 107). Initially, two factors (groups of participants with similar responses) were extracted, but only the EV for Factor 1 (1.51) indicating potential explanatory power (i.e. >1.00) and the presence of a single common factor in the study—i.e. Factor 2 was discounted as insignificant.

The factors are the rankings of items (Q Set statements) in comparison to the participants, with the items being treated as the sample rather than the participants. These factors are the building blocks of the participants' responses to the Q sort activity, when their responses are compared. Whilst the EV for both factors indicate potential explanatory power, the factor loadings above 0.33 for each participant (Table 1) indicate a significant loading in the responses for all except Participants 5 and 6 (Factor 2). A factor loading of 0.33 is considered to be a cut-off point in Q Methodology to indicate participant's inclusion in a factor (Watts and Stenner 2012). However the relatively low loading for Participants 3 and 4 may indicate a degree of divergence between them and the other 'members' of the factor.

The factor array for the Factor 1 Q-Sort (see "Appendix") provide a useful ranking of the statements, enabling common themes to be identified. They are presented with the 62 items (statements) in the Q Set ranked from +6 to −6, in a similar distribution to the 'forced-choice frequency distribution' described above (Fig. 1). However, it is important to note that the items that are ranked at the minus end of the spectrum do not necessarily represent disagreement, but rather that the participants arrange the items in a continuum from most agree (+6) to most disagree (−6), indicating the degree to which each were viewed as essential or desirable (respectively).

Discussion: competent management of the learning experience

As highlighted above, this is a single factor Q Methodology study due to the small sample size. The factor as an eigenvalue of 1.51 and explains 21% of the study variance. Five of the seven participants are significantly associated with the factor. In the original sample, there were five male participants, four of whom are associated with the factor, and two

Fig. 2 Correlation matrix between Q Sorts (n = 7)

	1	2	3	4	5	6	7
1	100	44	25	20	-3	16	16
2		100	21	17	-1	11	42
3			100	17	0	12	24
4				100	6	8	28
5					100	-2	9
6						100	-3
7							100

female participants, one of whom is associated with the factor. Two of the Factor 1 participants identify themselves as *product design* specialists, two as *graphic design* and one as *electronics and control*. Of the participants in the discounted Factor 2, one identified herself as *textiles and fashion* and the other as engineering.

Where a specific statement from the Q-Set is referred to, in the discussion below, the bracket items indicate (a) the number of the statement and (b) the relative ranking of the statement between the five teachers in 'Factor 1' (i.e. the degree to which the group agreed or disagreed with the statement). For example, (37: +6) indicated statement 37 "The teacher is competent to use equipment safely", which the group ranked strongly as *most agree*. The common features of the beliefs and values of the teachers in Factor 1 related, primarily, to the competency and clarity of the demonstrator. The findings are discussed below.

Competence and clarity

The highest rated statements relate to *competency* (37: +6) and *clarity* (1: +6) in relation to *subject knowledge* (see "Appendix"). Similarly the next layer of statements relate to the clarity of communication in relation to health and safety information (38: +5), learning outcomes (5: +5), explanations of processes and procedures (11: +5) and identification of the main teaching points or steps (17: +5).

Other key messages emerging in the 9 highest ranked items (Table 2), relate to *classroom management* and *expectations* of learning, and are somewhat teacher-centric as might be expected when the participant were prompted to reflect on their practice. The classroom management items are preparation for the demonstration area (32: +4) and the teacher monitoring or scanning the class to ensure that learners are safe (47: +4). Ranked outside the top ten (at 12) was scanning the class to monitor progress (53: +3), although this diagnostic approach would require some further exploration to define how the participants measure progress during and following a demonstration. The participants' expectations related to high standards in designing and making (39: +4) and explanation of how learners will make progress (59: +3).

Outside of the highest ranked items, two interesting features emerge, the first relating to the *consolidation of learning*, within the mid-range of statements (ranked between +2 and

Table 2 Highest ranked items (ranked +4, or above)

The teacher gives an overview of the content of the skills or knowledge being demonstrated **(1: +6)**
The teacher is competent to use equipment safely **(37: +6)**
The teacher presents the learning outcomes (i.e. what learners will do or be able to do as a result) **(5: +5)**
The teacher gives clear verbal explanations of processes and procedures **(11: +5)**
Appropriate information about risk is readily available to learners **(38: +5)**
The teacher identifies the main points/steps for the learners **(17: +4)**
The teacher prepares the demonstration station/area in advance (e.g. before the lesson) **(32: +4)**
The teacher sets high standards and expectations for the learners in designing and making activities **(39: +4)**
The teacher scans and monitors the group to ensure that learners are safe **(47: +4)**

Statement number and factor array ranking in bold

−2), and the second relating to *learners' choices* and *independent learning*, in the lower-range (−3 to −6).

Consolidation of learning

In the mid-range statements two themes emerge relating to the consolidation of learning and to the teacher's role in probing learners' understanding concepts and processes (27: 1) to recall (26: −2) and apply knowledge from both within (26: −2) and outside of the immediate learning experience of the current unit being taught (23: +2), other design and technology units (24: −1) and from other subjects (25: −2). In addition, the teacher's role in using questioning to ascertain what learners understand (58: 0) and addressing their misconceptions as they arise (21: 1); both of which require a secure level of subject knowledge from the teacher in addition to pedagogical skills. The second theme relates to learners' emerging independence facilitated by the teacher allowing them to attempt a task, following a demonstration, before intervening (54: 0) and the use of peer learning to demonstrate skills/knowledge to each other (43: −1) and provide support before seeking the teacher's assistance (55: −1). This requires a degree of self-discipline from the teacher to defer intervention and to invest time to develop a collaborative learning environment.

Learners' choices and independent learning

Statements relating to the consolidation of learning continue to emerge in the lower-range statements, with focus on: the teacher identifying (40: −6) or learners being enabled by the teacher (41: −3) to make choices or take alternative actions; learners speculating with prompts through teacher questioning (28: −3); or thinking-out-loud to consolidate learning (50: −5). The ranking of these items in the lower-range does not necessarily indicate a lack of importance or value placed on the independent learning, although this may be the case and would suggest the need for further study; it could also be the result of the necessarily restrictive nature of the demonstration of skills and knowledge requiring learners to follow defined and predetermined processes. An increasing focus on the learner's independence is reflected in the various psychomotor domains for taxonomies of learning objectives, such as Simpson (1972) or Dave (1967), developed following the development of the cognitive domain by Bloom et al. (1956) and the affective by Andersen and Krathwohl (2001). As the principle investigator, Simpson drew from expertise in practical subjects (Industrial Arts, Agriculture, Home Economics, Music, Physical Education and Art), identifying adaption and origination as the highest levels (Table 3). It also reinforces the notion that

Table 3 Simpson's psychomotor domain

Level	Description
Perception	Observation and general perception
Set (or mindset)	Cognitive readiness for action
Guided Response	Imitation and mimicry when practicing actions
Mechanism	Emerging competence/proficiency, leading to independence
Complex Overt Response	Independence, automatic and accurate performance
Adaptation	Mastery and the ability to transfer skill/knowledge to other settings
Origination	The ability to create new approaches to activity

the demonstration was viewed by the teachers as an essentially restrictive, as opposed to expansive, teaching method (Fuller and Unwin 2003).

Traditionally these levels of competence have been considered to belong to the craftsman through a lengthy apprenticeship (Sennett 2009, 2008). So it is not surprising to see the role of the demonstration as a signature pedagogy in design and technology, within a subject-based national curriculum espousing a "balanced and broadly based" (DFE 2013, p. 5) learning experience. The ranking of items relating to the role of the teacher to make learners aware of choices, encourage them to speculate on the next steps or 'think-out-loud' to consolidate knowledge, indicates that these pedagogical strategies may be less commonly employed and/or desirable. The learning at the adaption and origination end of the psychomotor domain is predominately expansive, as opposed to restrictive, suggesting that demonstration through teacher modelling and explanation may be less appropriate; and learner-led approaches such as microteaching, which is an effective learning method (Hattie 2009), may be more appropriate.

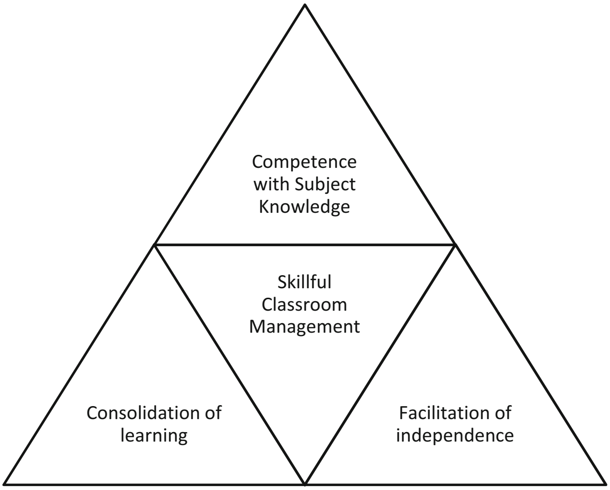
Planning, preparation and resources

Three statements in the Q-Set related directly to planning (8-10) and six to the use of resources (29–34). The participants in the factor group expressed a preference for staged demonstrations (8: +2), breaking down complex processes, over modelling the whole process in one demonstration (9: −6). The low rating of the latter does not imply disagreement, but hints at a bias towards the *just-in-time* over the *frontloaded* approach. It also implies some form of rehearsal, whether cognitive for experiences teachers or real-time for novices. Preparation of the demonstration are (32: +4) featured in the highest ranked statements (Table 2). Another trend identified in the lower-range statements, relates to the use learning and human resources to support demonstrations. These include the use of resources, such as instruction sheets, slideshows and videos (33: −3), images, photographs and diagrams (29: −4), ICT to simulate or model a process (20: −5), and the use of support staff during or after the demonstration to support learners (34: −4). This was a somewhat unexpected outcome, and would suggest the need for further research to investigate this relatively low ranking of potentially useful approaches to support verbal explanations with visual reinforcement, through dual coding (Clarke and Paivio 1991).

Conclusion

As previously stated, the act of demonstrating is complex and nuanced, drawing on both generic and subject-specific pedagogical teaching methods (in particular teacher modelling and explanation). Whilst this study does not seek to propose theoretical framework or typology, it develops on the discussion begun by McLain et al. (2015). The responses in this small-scale study support the belief that competence in relation to design and technology subject knowledge is fundamental to effective teacher modelling, supported by skilful pedagogical knowledge to manage the classroom; with the sophisticated skills to consolidate learning and facilitate independence being employed as appropriate to the age and ability of the learners (Fig. 3). DfE (2013) presents the content of design and technology for 14 to 16 year olds in two categories: technical principles and designing and making principles. Whether it be in relation to the properties of material or specific making techniques, the designed artefact (be it referred to as product, system or prototype) is a

Fig. 3 Visual representation of participants' responses



fundamental aspect of design and technology activity. Whilst there are basic concepts that can be described, such as the fact that most materials can be shaped using "wastage, addition, deforming and reforming" (p. 6), different materials have distinct means (e.g. tools and techniques) for achieving these ends. Therefore, this paper argues that the demonstration is a fundamental, or signature, pedagogy in design and technology education to support knowledge transfer; albeit within a relatively restrictive pedagogical paradigm, and other aspects of design and technology knowledge would benefit from more expansive approaches, embodied in discovery learning activities central to design and technology such as designing and making.

As a Q Methodology study, the analysis of the findings indicates the common ground between the participants in response to the 62 predefined statements on teacher modelling and explanation in design and technology. This paper explores, in more depth, the findings from the initial and exploratory small-scale study by McLain et al. (2015), which present subject knowledge and classroom management at the heart of teachers' beliefs and values. Further research is needed to explore the emerging patterns of beliefs about teacher modelling and explaining in design and technology, and McLain (2016) reports on a subsequent study involving teacher educators, using the same set of statements, which will be explored in depth with a second paper. Initial finding from McLain (2016) suggest potential avenues to develop and refine of a more concise set of statements. This study nine of the highest ranked items (Table 2), which could be used to inform discussion, debate and observation of learning in initial teacher education and for training school-based mentors.

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Appendix

Q-Set: 62 items (statements) relating to teacher modelling, explaining and questioning in design and technology, with factor array (ranking):

No.	Item	Category	Array
1	The teacher gives an overview of the content of the skills or knowledge being demonstrated	Content	6
2	The teacher uses technical language/terminology and key words	Content	3
3	The teacher presents their expectations	Content	3
4	The teacher presents the learning objectives (knowledge/skills)	Content	3
5	The teacher presents the learning outcomes (i.e. what learners will do or be able to do as a result)	Content	5
6	The teacher refers to the application, of what is being demonstrated outside the classroom context	Content	1
7	The teacher demonstrates skills and knowledge that learners will apply within the lesson	Content	1
8	The teacher uses staged demonstrations, breaking down more complex process into separate (linked) demonstrations	Planning	2
9	The teacher models/explains the whole process in one demonstration	Planning	-6
10	The teacher adapts their approach and style of demonstration to the learners, dependent on age, ability, prior experience, etc.	Planning	1
11	The teacher gives clear verbal explanations of processes and procedures	Explanation	5
12	The teacher provides a running commentary through the demonstration	Explanation	0
13	The teacher gives clear models/examples processes and procedures	Explanation	2
14	The teacher makes reference to relationships with other related concepts (e.g. mathematical, scientific, technological, etc.)	Explanation	−1
15	The teacher make reference to cause and effect of decisions and/or actions	Explanation	−2
16	The teacher uses examples, analogies and/or similes to explain processes and procedures	Explanation	−2
17	The teacher identifies the main points/steps for the learners	Explanation	4
18	The teacher 'signposts' or indicates the next steps (i.e. "later in the lesson…" or "in next lesson…")	Explanation	0
19	The teacher models diagnostic processes, such as using testing equipment to fault-find or the application of scientific knowledge from an observation	Explanation	−2
20	The teacher uses ICT to simulate or model process or products	Explanation	−5
21	The teacher addresses learners misconceptions as they arise	Explanation	0
22	As part of the planned demonstration, the teacher addresses common misconceptions around technical terms, concepts, etc.	Explanation	−1
23	The teacher uses questioning to probe learners' prior knowledge from within the unit/project	Questioning	2
24	The teacher questioning to probe learners' prior knowledge from previous D&T units/projects	Questioning	−1
25	The teacher questioning to probe learners' prior knowledge from other subjects	Questioning	−2
26	The teacher uses questioning to enable learners to recall aspects of the process demonstrated	Questioning	−2
27	The teacher uses questioning to probe understanding of concepts, process and procedures	Questioning	1

No.	Item	Category	Array
28	The teacher uses questioning to encourage learners to speculate (e.g. predicting the next step in a process)	Questioning	−3
29	The teacher uses visual resources, such as images, photographs and diagrams, to enhance their demonstrations	Resources	−4
30	The teacher prepares and uses examples of the products/outcomes being demonstrated	Resources	0
31	The teacher prepares examples showing the steps/stages of the process being demonstrated	Resources	−1
32	The teacher prepares the demonstration station/area in advance (e.g. before the lesson)	Resources	4
33	The teacher uses resources, such as instruction sheets, slideshows or videos, after the demonstration to support learners	Resources	−3
34	The teacher uses other support staff (i.e. technician or teaching assistant) during, and after, the demonstration to support learners	Resources	−4
35	The teacher identifies hazards and risks for the learners	Health and Safety	1
36	The teacher prompts learners to identify hazards and risks for themselves	Health and Safety	2
37	The teacher is competent to use equipment safely	Health and Safety	6
38	Appropriate information about risk is readily available to learners	Health and Safety	5
39	The teacher sets high standards and expectations for the learners in designing and making activities	Challenge	4
40	The teacher identifies alternative actions or choices learners can or need to do (e.g. design, make, evaluate)	Challenge	−6
41	The teacher enables learners to identify alternative actions or choices that they can make (e.g. design, make, evaluate, etc.)	Challenge	−3
42	The teacher plans and uses extension or enrichment activities for able learners	Challenge	−4
43	The teacher encourages/supports learners to demonstrate skills and knowledge to their peers	Challenge	−1
44	The teacher encourages learners to participate in fault finding and quality control	Challenge	−2
45	The teacher ensures that they make eye contact with members of the whole group	Engagement	0
46	The teacher scans and monitors the group, as they are teaching, to ensure that the learners are engaged	Engagement	2
47	The teacher scans and monitors the group to ensure that learners are safe	Engagement	4
48	The teacher has 'presence' within the classroom	Engagement	−1
49	The teacher can modify their tone when talking to/with different sized groups and in different situations	Engagement	−3
50	The teacher encourages learners to 'think-out-loud' to consolidate knowledge and understanding	Engagement	−5
51	The teacher explains the function and/or context of the matter (i.e. knowledge and/or skill) being demonstrated	Engagement	−5
52	The teacher encourages learners to reflect on values (e.g. the impact of a technology on society, the environment, etc.)	Engagement	−3
53	The teacher scans the room after the demonstration to monitor learners' progress	Learning	3
54	The teacher waits for learners to attempt a task before intervening	Learning	0

No.	Item	Category	Array
55	The teacher encourages learners to support each other before seeking the assistance of the teacher	Learning	−1
56	After the demonstration, the teacher moves around the room to support learners	Learning	1
57	The teacher shows/explains the process/skill to individuals who have misunderstood processes or concepts shortly after a demonstration	Learning	−4
58	The teacher uses questioning to ascertain what a learner understands, when they have not fully understood the demonstration	Assessment	0
59	The teacher explains what learners are expected to do to make progress	Assessment	3
60	The teacher makes his/her expectations of the learners' outcomes clear	Assessment	2
61	The teacher provides examples of outcomes of a process that exemplify the skills being modelled	Assessment	0
62	The teacher ensures that all learners know what they need to do to make progress	Assessment	1

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