An open learning system for special needs education

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Abstract: The field of special needs education in case of speech and language deficiencies has seen great success, utilizing a number of paper-based systems, to help young children experiencing difficulty in language acquisition and the understanding of languages. These systems employ card and paper-based illustrations, which are combined to create scenarios for children in order to expose them to new vocabulary in context. While this success has encouraged the use of such systems for a long time, problems have been identified that need addressing. This paper presents research toward the application of an Open Learning system for special needs education that aims to provide an evolution in language learning in the context of understanding spoken instruction. Users of this Open Learning system benefit from open content with

novel presentation of keywords and associated context. The learning algorithm is derived from the field of applied computing in human biology using the concept of spaced repetition and providing a novel augmentation of the memorization process for special needs education in a global Open Education setting.

Keywords: Speech and language therapy; Special needs open learning; Game-based learning, Spaced repetition

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1. Introduction

Recent technological advancement in mobile computing has fostered innovation in special needs education in case of speech and language deficiencies, especially when considering Speech and Language Therapy (Sutton & Olivier, 2013). The Internet of Things and the plummeting cost of access is enabling more people and devices to become connected to the Internet, effectively the entire world is now able to access computing resources, data, services, and open content at anytime, regardless of location and without subscription costs. This realization has brought a plethora of diverse systems designed to assist with the evolution of traditional models and approaches in a variety of fields. These systems have effectively resurrected the concept of Open Learning and Open Education in the sense that delivery can now be accomplished as the learner desires rather than where the educator exits (Zawacki-Richter, Baecker, & Vogt, 2009). While such Open Learning systems have enabled many professionals and students to enhance their knowledge and understanding and effectively deliver education in ways and methods that could not have been imagined in the past (Downes, 2007), more importantly they are now enabling those with impaired access to education and resources to achieve their potential (Connor, Gabel, Gallagher, & Morton, 2008).

In the field of special needs education in case of speech and language deficiencies, Speech and Language Therapy (SLT) systems are required to complement the structured learning session aiding the Speech and Language Professional (SLP). More recently, there has been a noticeable rise in the number of applications affecting a move toward more individual, mobile, and personalized learning that is motivated by evolving social and computing paradigms of the age.

The SLT has seen great success in the utilization of a number of paper-based systems to help young children experiencing difficulty in language acquisition and understanding. These systems employ card and paper-based illustrations, which are combined to create scenarios for the child to expose them to new vocabulary. While this success has encouraged the use of such systems for a long time, problems have been identified that need addressing. For example, the need to keep a child's attention focused on the task at hand (Brown, 2013). Coupled with the desire to embrace recent advances in technology to move forward from a paper-based approach and effectively expand the concept of Open Education to all, this has led to the possibility of a computerized solution and pervasive content availability for special needs education.

Current research has shown that a computerized system can provide a more entertaining and interactive experience for both therapist and learner (Brown, 2013). Initial implementations have reported promising results about the effects of using technology in support of traditional learning methods. However, there seems to be a consensus that a lack of quantitative data about the efficacy of a mobile access to open data in the context of Open Education still exists. Therefore, there is a need to explore the use of new (mobile) technology to garner further evidence about the efficacy of its use (Brandenburg, Worrall, Rodriguez, & Copland, 2013).

Especially of interest is the research direction toward Open Learning applications developed to support the traditional techniques of SLT. The functionality of these applications must mirror existing systems but provide a more interactive way for learning as well as general access for all users. Sutton and Olivier (2013) examined a wide range of speech and language applications regarding their utilization in the home environment. When referring to current technology uses in SLT, it is argued that despite their effectiveness, SLT applications are very often "simplistic remediation of the paper

resources of therapy techniques already used." It is in this vein that the research presented in this paper is drawing on other knowledge domains to create an Open Learning system that augments the traditional SLT systems and processes and offers unlimited opportunities to be accessed by various stakeholders devoted to special needs education. This research builds on a new approach to language learning in adults in the field of applied computing in human biology; Leitner (2011) proposed a technique to provide a system of time-optimized learning known as "spaced repetition" to aid the retention of facts and knowledge. The application of this methodology has revolutionized language learning, as demonstrated by companies such as Pimsuler, a multimillion dollar corporation that has successfully leveraged Leitner's techniques to great effect. It has also seen success in the public domain where free applications such as Anki (2012) and Skritter (2012) have amassed a user-base numbering in the millions.

This paper presents a study aimed to identify the areas of existing paper-based SLT systems that have the potential to be improved using applied computing in human biology from an Open Education viewpoint. Central to this research is testing the hypothesis that "the Open Learning approach improves upon the existing systems from both a Learner and Therapist's perspective".

This paper is organized as follows: related works are detailed in Section 2, and Section 3 presents the development strategy of the proposed system. In order to systematically determine the applicability and worth of this system, Section 4 covers the experimental as well as evaluation procedures. Section 5 addresses future research directions.

2.   Evolution of existing systems

The earliest years in a child's life are absolutely critical period in a child's development (Freeman & Hartshorne, 2009). Research has shown that Speech, Language, and Communication Needs (SLCN) of children fall within a wide spectrum of variability. SLCN is an umbrella term that refers to the specific needs of the child and encompasses the manner in which support can be given (Bercow, 2008). SLCN variability can be measured in varying contexts, such as primary speech, language, and communication difficulties; cognitive and sensory impairment (Locke, Ginsborg, & Peers, 2002); socioeconomic disadvantage; and underexposure to conversation (Hart & Risley, 2003). Of particular concern is recent evidence that suggests children hailing from backgrounds of poor Socioeconomic Status (SES) are not achieving when compared to their peers in other more affluent or socially enabled demographics. Indeed, studies have shown that initial growth in expressive communication is higher in children from high SES demographics (Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009). The need to properly meet the SLCN of children in early years has been identified as an important factor in driving both oral and literacy skills. This is due to the fact that early spoken language skills underlie subsequent reading and writing skills (Locke, Ginsborg, & Peers, 2002).

Children with SLCN will typically exhibit an impaired ability to understand and/or use words in their proper context, whether verbal or nonverbal. These difficulties can have a cascading effect on other areas of the individual's life over time. Psychological, social, and behavioral problems can emerge due to a dependence on poor communication skills (The Communication Trust, 2013). It has been suggested that early intervention is essential in attempting to equalize a child's early experience with other

children who do not require SLCN. Consequently, intervention can be presented in different forms depending on the severity of the child's needs.

It has been estimated that 7% of children of school age (nearly 40,000 in the UK) experience difficulties with speech and language and thus require SLCN support (Bercow, 2008). In cases of mild delay, early support and intervention may allow for the individual to close the gap with their peers (The Communication Trust, 2013). However, children with more persistent SLCN may require additional long-term support through the provision of an SLP in order to affect a long-term improvement in speech and language skills. In each individual case, a thorough needs assessment is carried out to determine the level of intervention required based on set guidelines such as those outlined by Bercow (2008).

In this approach, recent studies have confirmed that regular structured intervention can deliver "significant improvements in age corrected standardized scores for receptive language". According to Boyle, McCartney, Forbes, and O'Hare (2007) the most widely used intervention is based on individual work with a language therapist. This is considered to be the most costly form of intervention as opposed to group-based activities, but the most effective in terms of results. The study also highlights the need for the efficient use of a therapist's direct and indirect time (delivery of sessions and preparation time) as a key factor with regard to economic costs. Additionally, according to the Royal College of Speech and Language Therapy (RCSLT the provision of SLT in the UK generates large annual benefit–cost ratios, thus justifying the use of public resources in this regard. Against this background, the application of Open Learning systems appears a promising way of spreading opportunities for continuous learning, diagnostic decision-making, and enhanced learner-therapist interactions.

2.1. Intervention

As highlighted by the Department for Education in Great Britain as part of their exploratory research project, intervention methods utilized to affect an increase in speech and language skills in children that exhibit SLCN exist over a wide spectrum of variability and are tailored to the needs of the learner. The more common methods and approaches employed (in order of high frequency) are modeling, forced alternatives, repetition, visual approaches to support languages, and reducing distractions. Boyle, McCartney, Forbes, and O'Hare (2007) defined these processes in detail:

- Modeling. This process entails a model or an example on how to communicate. It encourages innate language development through the modeling of others.

- Forced alternative. It describes the process of positing a "closed question" to a learner by providing a choice of two or more objects, with a view of eliciting a verbal response as to which one is the target object.

- Repetition. Being fairly self-explanatory, it reflects the need to "maximize the number of times a structure is heard" in order to "bring it to the child's attention." In this context, it is recommended to introduce clarification strategies that allow the child to seek additional information when unsure of how to proceed with a given task.

- Visualization aids. They can provide support in addition to mere spoken language. Important characteristics and portions of words can be associated with a visual mnemonic to aid retention, elicit understanding, and gain insight.

- Reducing distractions. This process is considered to be an essential step performed when monitoring comprehension to make sure a child has fully understood what has been said.

As mentioned previously, the interventions utilized in SLT are comprehensive and only the most common subset of approaches has been illustrated here.

2.2. Delivery of intervention

Current delivery mechanisms for learning sessions include primarily paper-based resources for structured activities and play sessions for the children to participate in. In the context of language comprehension, a number of paper-based systems are utilized to deliver these activities. Guidelines are provided that address specific levels of language comprehension, detailing available words grouped by unit of meaning, or morpheme (Bowen, 2013), to make sure that activities are structured around a child's comprehension level. Activities are created at the discretion and creative whim of the therapist, adhering to the guidelines and tailored to the needs of the child. Vocabulary learned at previous "levels" is available to use at later levels, forming compound phrases and sentences, containing an increasing number of morphemes. At higher levels, operations of reference (i.e., that's a car) and the use of semantic relations (i.e., the spider is on the table) are employed to build the comprehension of both meaning and application. Context plays an important role in the delivery of language and its perception. Activities are typically delivered through the manipulation of paper-based avatars and illustrations, physical objects, or actions, as illustrated in Fig. 1.
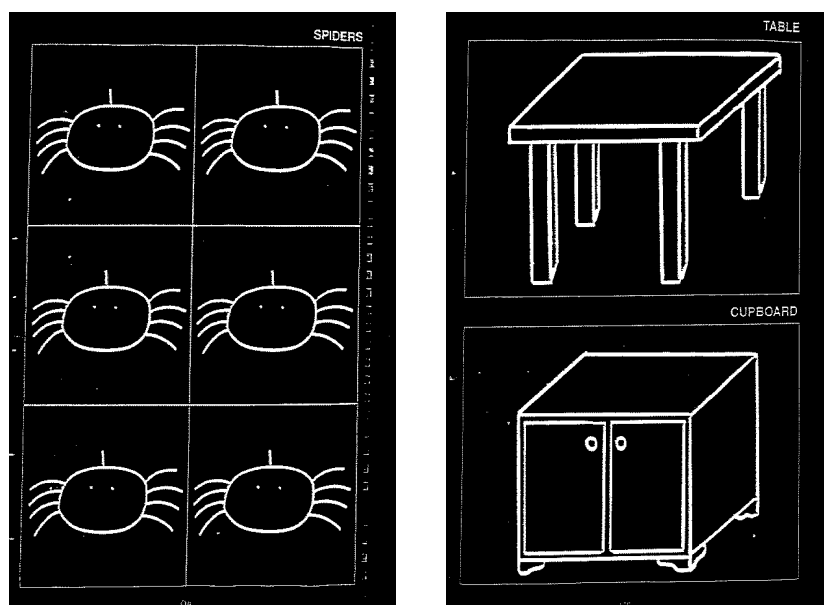
Fig. 1. Examples of paper-based avatars and illustrations

A noted challenge for SLPs is keeping children motivated and engaged with their learning activities during therapy (Brown, 2013). Therefore, an important secondary objective of an SLP regarding the overall success of a session is to keep the child engaged through the use of achievable intrinsic and extrinsic rewards that the child can

strive toward, and an emphasis on making the overall session fun and enjoyable. While the paper-based methods are underpinned by empirical research and are proven to assist in language development, one of the main criticisms of these systems is their inability to engage and hold a child's attention. Another secondary concern is the large investment of time and resources required to prepare a session with paper-based systems (Stephen, Stevenson, & Adey, 2013). Although the success of the current UK NHS paper-based approach to SLT delivery has encouraged the use of such systems for a long time, recent advances in technology have encouraged the evolution of the existing systems. According to Brandenburg, Worrall, Rodriguez, and Copland (2013) a computerized system has the potential to allow for a more entertaining and interactive experience for both therapist and learner. Technology is considered to be more accessible and engaging, efficient at holding the attention of a child for longer periods, convenient, inexpensive, and easily accessible (Sutton & Olivier, 2013). Recently, the proliferation of mobile devices is enabling therapists and special needs educators to take a fresh look at how mobile applications can support their practice. Thus, a key motivation for this research work is to augment knowledge from various fields and provide novel methods of SLT delivery through technology.

2.3. Spaced repetition system

This Sub-section addresses the SRS design. The logical process is outlined as a rule-based system with emphasis placed on data manipulation to preserve the metadata attached to cards. The data that drives the SRS resides in a relational database stored on the server.

The logic of the SM-2 SRS algorithm (Wozniak, 2011) is based on the creation of a deck of SRS "cards" comprising one- and two-word-level animations, association of a corrective E-factor, assessment of the quality of repetition response in a 0–5 grade scale and subsequent modification of the E-Factor of the recently repeated item according to the following formula:

$$EF: = EF + (0.1 - (5 - q) * (0.08 + (5 - q) * 0.02))$$

where EF is the new value of the E-Factor, EF is the old value of the E-Factor, and q is the quality of the response in the 0–5 grade scale. If EF is less than 1.3, then EF will be 1.3. If the quality response was lower than 3, then repetitions start for the item from the beginning without changing the E-Factor. After each repetition session of a given day, all items scored below 4 will be repeated again in the quality assessment. The repetitions continue until all of these items score at least 4.

The development of the Anki (2012) application has opened a debate about the length of each interval for spaced repetition. The SM-2 algorithm is slightly amended in the proposed Open Learning system to fit the requirements explained in Section 3.

2.4. Metadata

Each animation or "card" has associated metadata to drive the SRS. Applying this metadata, decks of animations are profiled according to the users who can progress with the system tailored to their needs. Metadata per card include, but is not limited to, the following:

- Unique card identifier
- Associated Leitner box number

- Order number (position in the deck)
- Date of last repetition
- Date of next repetition
- SM2 associated variables
  - Last interval
  - Easiness factor
  - Quality response
- Associated deck user ID (to identify which user the deck belongs to)
- Associated performance data (for system and user progress evaluation)

The relational database to house this metadata includes three entities: Users, Decks, and Stats. The Users entity holds all data as it pertains to the identification of each user in the database. It relates directly to the Decks entity whereby each set of cards in a deck is annotated with user data to identify which deck belongs to whom. The Stats entity uses data in the other two entities to track performance and evaluate the system in the evaluation stage.

The SRS for special need education in an Open Learning approach is a web-technology-based client–server application. Thus, the system allows for learning at own pace, and can be accessed at any place and in any home, hospital or school setting, online or mobile. The design features are outlined in the next Section.

3. The Open Learning system

This Section details the functionality of the Open Learning system for special needs education, which overall components are demonstrated in Fig. 2. With regard to the inherent SLT assistance, vocabulary is delivered through user-invoked animations, presented at varying degrees of difficulty. The user is tested on the comprehension of keywords based on activities that mirror those used by the NHS currently. The keyword "object" is presented in a scene with two other objects; the user is then asked to pick out the keyword object from this selection. The spaced repetition algorithm works behind the scenes to reinforce the learning of these keywords by scheduling reviews of cards –the user is struggling with – to appear at more frequent intervals. Moreover, activities are provided to aid with the comprehension of spoken instruction aimed at children who have a good mastery of the systems basic vocabulary.

The application is data driven, requiring access via the network link to a data repository and associated service. Security and anonymity were noted, as requested features but are not included in the prototype due to time constraints. The main features of the application are segregated into two categories, namely, front-end and back-end. Front-end features are presented directly to the user and provide an interface to the system functionality. They are essential for the system to operate in a logical manner. Back-end features are hidden from the user and are essential for the system to operate normally. The applications are delivered preferably through a tablet device. The system can be operated via a PC as a secondary delivery medium.
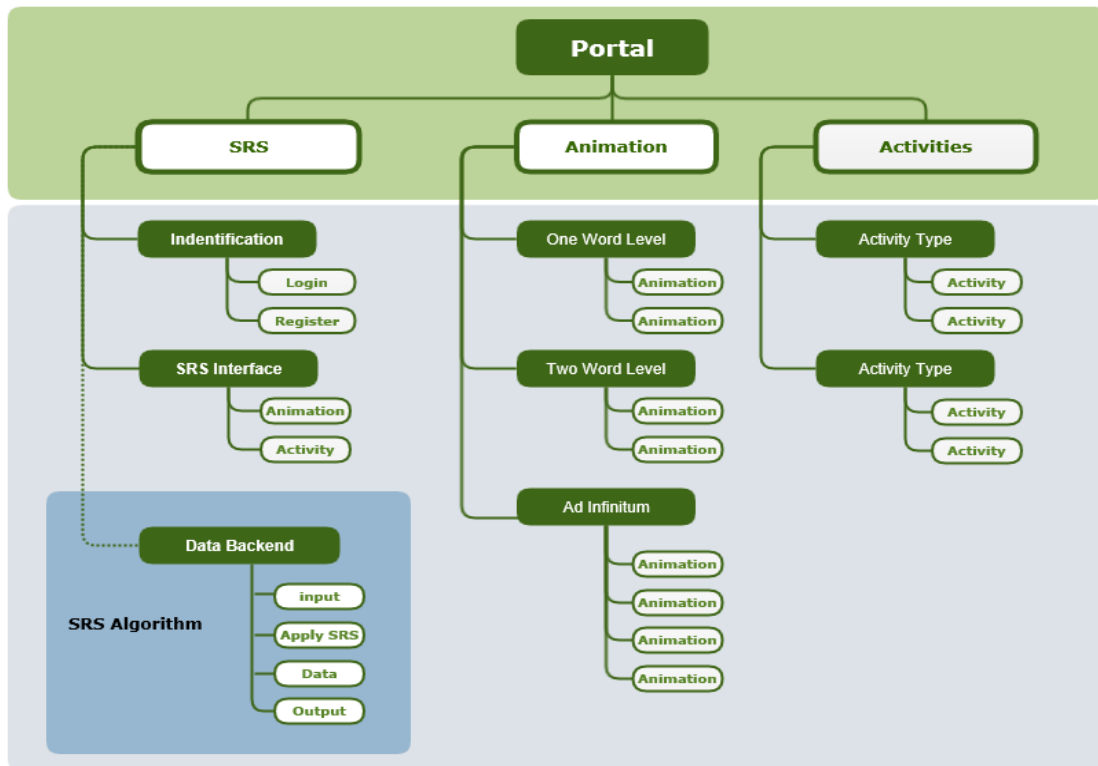
Fig. 2. Component overview of the Open Learning system

3.1. Potential application scenarios

The Open Learning system is intended to be utilized primarily by the SLP professional and learners in support of structured SLT sessions. However, once the user has become acquainted with the system features, this operation may be supported by further stakeholders, such as a parent or guardian. The learning curve of applications lies in understanding the purpose and terminology of the applications. Technical experience should not be considered an issue, and the user navigation is easy to use. Potential application scenarios refer to the following:

- SLP accesses specific animations to support creative SLT session
    - Provide access to all animations on demand
    - Therapist can tailor session to suit keywords (learner needs)
    - Touch screen gesture-driven commands invoke animation
- SLP accesses specific activity to support creative SLT session
    - Provide access to all activity on demand
    - Activities chosen can suit personal needs of learner
    - Touch screen gesture-driven commands provide intuitive interactivity with current task
- Learner casually browses application (with support from guardian)
    - Provide access to all areas of interest
    - Learner can access all animations and activities
    - Colorful imagery provides motivation to explore animations

- User access spaced repetition system
  - Provide authentication to tailor session to current user
  - Session state must persist between each session
  - SRS algorithm reorders activity according to learner performance
  - Animations are shown according to SRS repetition interval

3.2. System design and implementation

Based on the requirements and design features outlined in the previous Sections, Fig. 3 shows the sitemap of the proposed system. The system itself presents a series of open content in terms of animations to reinforce words at one- and two-word levels (predominantly one word at this time as a prototype). A keyword is spoken, and the word is put into context through animations. The keyword is then repeated. The user is asked to select an object, given a keyword, and progress is tracked to aid the comprehension of words that a user seems to be struggling with. Two-word level activities are also provided to place the words in context. The application is segregated into four sections:

- One-word level. This section contains a selection of animations to aid the comprehension of single words. The words were selected from the Early Years Language Resource at Mab Lane Primary supplied by the NHS SLP representative.

- Two-word level. The scope for creativity with the two-word level animations is much higher, but they take a longer time to create. The animations chosen are taken from the first two "possession" examples in the Lancashire Language Scheme Test of Comprehension.

- Spaced repetition system. This is the main feature of the application. Each child can create their own profile, and all the animations are sorted in order, presented sequentially as if they were a set of "flashcards." Once a "card" has been shown to the user, they will be tested on it in manner derived from the SLT session materials supplied by SLT SLP representative, in that a choice is presented with a keyword as the target object, among a set of objects. Each object presented is based on the words learned at the one-word level. The system then uses a process of spaced repetition to grade how well the user responds to the question, by monitoring for correct or incorrect choices.

- Activities. Six interactive animations have been created to serve as two-word level activities. Where possible, activities are based on vocabulary learned over the course of using the SRS. "Put the baby in the bed," for example, is a combination of "baby" and "bed" learned at one-word level. Further, a question is posed to the user, "Baby is tired. Can you put the baby in the bed?" The user has to drag the baby to the bed. If the user does not complete the activity in time, the question will be reposed, more slowly this time with emphasis on each word. Finally, the keywords alone are repeated "baby in bed" until the activity is completed. The activities are separate to the SRS activity and progress is not tracked.
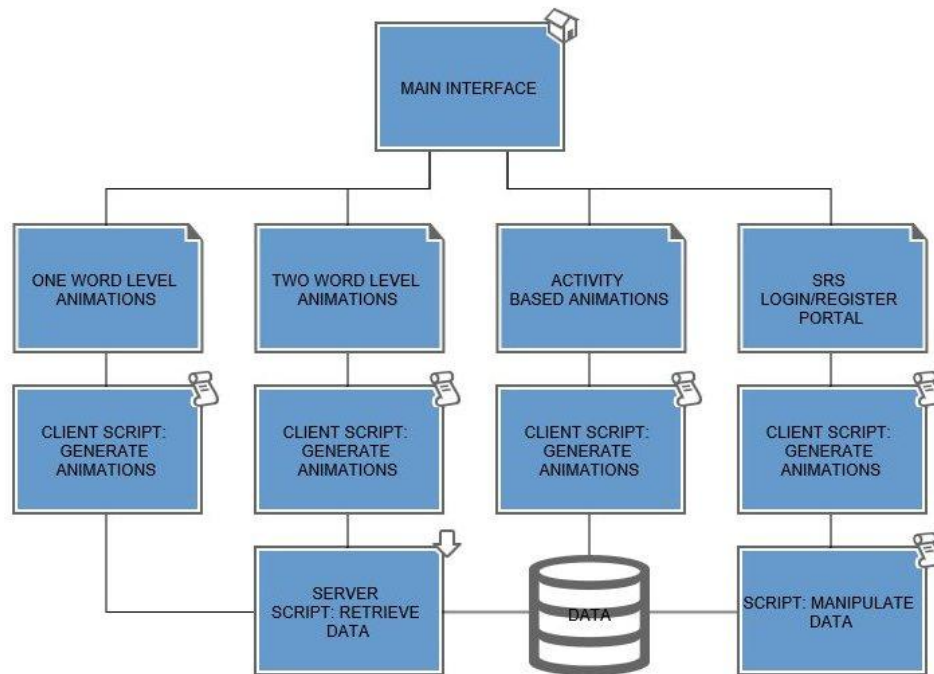
Fig. 3. High-level sitemap based on requirements

4. Evaluation of the proposed system

As a highlighted research objective, it was the intention of the authors to fully demonstrate and evaluate the system's efficacy within the Open Learning context in a structured learning session. The next Sub-sections illustrate the evaluation methodology and findings.

4.1. Structure of the questionnaire

The questionnaire seeks to evaluate each component of the system stressing on its ability to fulfil its purpose, namely, conveying spoken language to children toward understanding spoken instruction. First, the application as a whole is assessed in terms of its ability to keep a child focused on the task at hand, in addition to reducing session preparation time. Second, the animations are evaluated in terms of their ability to accurately convey their respective keywords, while also questioning the content of the animations themselves. SRS is then assessed toward its effectiveness at augmenting the learning process at the one- and two-word levels. Finally, the activity animations are evaluated regarding their ability to accurately test the child's new comprehension of spoken instruction. The posited statements that make up the questionnaire are listed in Table1.

Table 1
The questionnaire structure

	The application:
1.	With your guidance, the child finds application is easy to use.
2.	The application keeps the child engaged on the task at hand.
3.	There is a lengthy preparation period required to use the application.
	Animations:
4.	The overall presentation of each animation in terms of its visual content is confusing.
5.	Animation audio is too complex for one-word level.
6.	Animation audio is too complex for two-word level.
7.	Keywords are conveyed easily.
8.	The context presented in each animation assists in the comprehension of keywords.
9.	Animations hold the child's attention.
10.	Cartoon theme of animations is appealing.
11.	Animations provide a more efficient method of delivering a keyword than current paper-based resources
	Activities (e.g., Put the baby in the bed):
12.	Activities are useful in reinforcing keywords.
13.	Dragging of items is intuitive.
14.	Audio instructions are clear.
15.	Activities are engaging and hold the child's attention.
16.	Children are able to follow the audio instructions in order to complete activities.
	Spaced repetition system:
17.	The purpose of spaced repetition is clear to you.
18.	Your child is able to pick out a keyword object, from a series of objects, when using the SRS.
19.	The repeating of keywords and phrases at intelligent intervals aids comprehension.
20.	Once logged in, children are able to operate the SRS without assistance.

An important research objective when designing the application was to keep the child engaged. The test user age-group is young children from a local children hospital in Liverpool between the ages of 2 and 4 years, and as such, the application must be suitable for operation by children of this age-group. In accordance with the technology acceptance model, it has been argued that a major determinant of intrinsic motivation when adopting any technology can be derived from the perception of ease of use (Venkatesh, 2000). Therefore, in this section of the questionnaire, perceived ease of use is coupled tightly with perceived motivation of the child while using the application.

Animations were designed to convey a set of keywords normally utilized by SLPs, on a one-to-one basis, as part of their structured SLT session. The SLP is able to alter the manner in which these words are delivered in real time, when required by the child. A

present animation is not able to do this, and therefore, the efficacy of animations as a means of conveying spoken language must be evaluated. Opinions are gathered in terms of complexity of visual content, audio, comprehension, and the content of each animation.

Activities are derived from base animation templates, and consequently assessed in a similar manner. Endowing a child with the ability to complete these exercises is one of the main objectives of the application as a whole.

The concept of the spaced repetition was explained to each participating family prior to the evaluation process. Opinions were gathered on the effectiveness of the SRS at augmenting the memorization process. The activities represent a set of interactive animations designed to simulate the forced alternative method prevalent in SLT as outlined in the work of Boyle, McCartney, Forbes, and O'Hare (2007). Therefore, the activities are evaluated in the same manner as a standard animation. Additionally, the ability of children to complete each activity based on the answer to a three choice forced alternative is assessed here.

4.2. Results and discussion

Based on the questionnaire, a number of research questions conducive with satisfying the requirements of the research objectives were derived. The responses were evaluated and the outcome is summarized in Table 2, and discussed in the following.

Table 2
A summary of the results

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Engagement in the task	0%	0%	0%	20%	80%
Attention held by the animation	0%	0%	20%	20%	60%
Attention held by the activities	60%	0%	20%	20%	0%
Ease of use	0%	0%	20%	20%	60%
Need of preparation time	60%	40%	0%	0%	0%
Appealing application	0%	0%	0%	0%	100%
Animation content is confusing	60%	40%	0%	0%	0%
Keywords are conveyed easily	0%	60%	20%	20%	0%
Importance of context in conveying a keyword	0%	0%	20%	20%	60%
Activities are useful in reinforcing keywords	0%	0%	0%	0%	100%
Clear purpose of spaced repetition	0%	0%	0%	0%	100%
Children are able to provide a correct answer	0%	0%	0%	0%	100%
Intelligent intervals aids comprehension	0%	0%	17%	33%	50%

(1) Does a two-dimensional interactive animation in an Open Learning system assist in keeping a child motivated to complete the task at hand?

Engagement in the task. The responses fall on the positive side of the engagement scale. A family who selected "agree" completed the study with their 2-year-old child who had SLCN in terms of forming words. They stated that their child became fixated on a particular animation and wanted to repeat it several times before moving on.

Attention held by the animation. We can observe the general consensus that animations are largely interesting enough to hold the child's attention. A family that answered neutral added additional comments, indicating that their child showed a preference for certain animations, resulting in some animations not holding their child's attention because of desire to view other animations repeatedly.

Attention held by the activities. The results demonstrate that activities are supportive in holding the child's attention on the current task. Comments included concerns that the audio is too complex to be initially understood, and that the text-to-speech voice was at times confusing for the children. However, the rate of speech adjusts for children who are having difficulty answering the current question, and this was noted as the reason for activities not scoring lower regarding engagement.

Ease of use. It was important to associate opinions regarding ease of use with motivation and engagement based on the observations made in the technology acceptance model (Venkatesh, 2000). The results illustrate a positive trend in opinions toward the application's usability. Concerns were raised with regard to navigation matters. Parents recommended replacing the text-based prompts with visual or auditory navigation cues.

(2) Does the Open Learning system alleviate overburdening in terms of preparation time?

This research question addresses the problem of overburdening the SLPs in terms of preparation time, a problem identified over the course of the literature review. The results reveal that the preparation time required getting up and running with the application is not a concern. However, comments included that in order to use the SRS, the children required assistance to begin using the application, and to transition to the next card.

(3) Does the use of mobile access to Open Learning augment the language learning process?

This research question is related to opinions on the effectiveness of mobile access to Open Learning for aiding the speech acquisition process, while also assessing the appeal of mobile technology when used in this context. The results show an overwhelming positive response to the use of mobile technology as facilitator in the Open Learning context. However, parents expressed concerns regarding the use of mobile technology for this age, in that it should be used alongside other structured activity and play, utilizing a more kinesthetic hands-on approach.

(4) Is the Open Learning system efficient in terms of assisting in the comprehension of spoken language and instruction?

This research question aims to assess the efficacy of the system in terms of its ability to fulfill the research objectives. Therefore, most of the statements posited in the questionnaire were aimed at garnering some insight into related opinions as follows.

Animation content is confusing. The results illustrate a general disagreement with the above statement. This indicates that animation content is generally well understood by the participating children. Comments included concerns about busy animations distracting the child from a keyword, which is further illustrated in the following.

Keywords are conveyed easily. In this question, opinions tend toward the negative end of the Likert scale. Comments on reasons for this were that some animations, although engaging and enjoyable for the child, were overly busy with peripheral content, and as such, children began associating keywords with peripheral objects. It was noted that this was not the case for all animations but was enough of a concern to influence opinions on this matter.

Importance of context in conveying a keyword. This question focuses on each animation's ability to apply context to a given keyword object to enhance understanding of a keyword objects function. An example of this would be the keyword "bed," followed by an image of a character sleeping in the bed. Context plays an important role in the delivery of language and its perception. The results illustrate that the delivery of keywords in context was regarded as important in the comprehension of keywords. Further comments on this subject stated that the context framing the keyword was the key factor in engaging a child and assisting in making a functional understanding of the keyword, its function in the real world, and its appearance.

Activities are useful in reinforcing keywords. Activities are utilized as a method of both introducing a child to spoken instruction and testing a child's comprehension of all the words at a particular level. As shown in results, all of the child's work when using the application leads to this point where they are tested on their ability to comprehend spoken commands.

(5) Does the spaced repetition system help to augment the learning of keywords with a view to building a framework for understanding spoken language?

Clear purpose of spaced repetition. The results undoubtedly show that, after fully explaining the space repetition concept to each participant, its purpose for learning of keywords was clear. Armed with this knowledge, statements could now be fashioned to explore opinions of the usefulness and efficacy of the SRS system implementation.

Children are able to provide a correct answer. Further, opinions on the children's ability to provide the correct answer to a forced alternative when using the SRS are being collated. The results point out that all parents agree that the SRS was effective at teaching their children new words. Initial answers to these questions were on the lower end of the Likert scale. As the parents agreed to use the system for another week post analysis, a short time after the initial results were collected, they expressed a desire to change their responses based on improved outcomes they were seeing through more exposure to the system.

Intelligent intervals aids comprehension. The term "intelligent intervals" refers to the manner in which the SRS reorganizes cards to expose the child to information they need to focus on. In general, participants agree that the repetition of content that a child is having trouble with memorizing, aids comprehension, which is a fact demonstrating the effectiveness of the Open Learning approach where learning can happen anytime in any online or mobile setting.

4.3. Reflection and recommendations

The overall goal of this research was to create a modern Open Learning system utilizing Internet and mobile technology to assist the current delivery of special needs education in case of speech and language deficiency to small children. Therefore, it is important to emphasize that the success of the current paper-based systems was recognized and built the basis for extracting features for the new development. In addition, the most common methods of intervention highlighted by the Department of Health in the UK (Roulstone, Wren, Bakopoulou, Goodlad, & Lindsay, 2010) were applied for feature extraction. The most frequently employed SLT aid, the process of modeling, served as a basis from which to create animation content. Keywords are spoken and re-enforced through the use of visual context. The second most utilized form of learning aid is the forced alternative, namely identifying a keyword from a set of related words. This process is simulated in the Open Learning system through use of interactive animations displayed as a pair, along with its associated model animation. Both the process of modeling and the use of a forced alternative are delivered as an animation pair by the SRS in a similar manner to the paper-based system.

Exploring the results, we can summarize that the children were engaged in both processes when using the system. In particular, the use of interactive cartoon-themed animations was attributed to the increased engagement time, and this shows promising results for the utilization of this presentation format in this context. The ability to hold the child's attention on the current task is identified as a major research objective, and as such, the positive results confirm the application's ability to achieve this goal.

It was also important to recognize that the delivery of keywords in the paper-based system was compartmentalized into progressively more difficult levels of comprehension. One- and two-word levels generally consisted of one or two static objects, and therefore, the design of the animations that derive content from these tasks should not overwhelm the child. Parents revealed that the animation content was overly not confusing for the child and emphasized the importance of the associated context with each keyword in achieving real understanding of its meaning. However, concerns were raised that some animations had the effect of distracting the child from the keyword itself, when the context around the object was introduced. These observations were made at the two-word level as animations became more involved. The results indicate that some content design would need to be revisited in a further system iteration.

As highlighted in the work of Boyle, McCartney, Forbes, and O'Hare (2007), a research objective was to assess the application's ability to reduce the overall preparation time for a structured learning session. The results point at a general consensus that through the combined use of the mobile technology and the application interface in the Open Learning system, there was not a lengthy setup and preparation time required. While these findings point to some possible reducing the overall preparation time for the therapist, a proper comparative analysis between the paper-based and the Open Learning system needs to be undertaken.

The question of the efficacy of mobile in the context of Open Learning in case of speech and language deficiencies has been posited prolifically in the literature; especially the work of Sutton and Olivier (2013) and the Brandenburg, Worrall, Rodriguez, and Copland (2013) study emphasized this question and the drive to modernize. Against this background, a number of research questions were posed in the evaluation related to the efficacy of mobile technology for Open Learning when used to aid speech and language acquisition. Parents overwhelmingly agreed that mobile technology is an appealing

medium for their children to carry out these kinds of tasks in an Open Learning context, with an intuitive and fast learnable interface.

5. Conclusion

The research aim of this work was to not create an exact digital representation of the current paper-based methods for special needs education in case of speech and language deficiencies but to apply a widely utilized learning and therapy aid, "repetition," as outlined by Roulstone et al. (2010). The content delivery system for keyword animation is driven by a spaced repetition algorithm derived from the work of Leitner (2011) and Wozniak (2013) with a view to augmenting recall of vocabulary. The developed Open Learning system for special needs education is an evolution in language learning systems toward understanding spoken instruction. Experiments have shown that users of this Open Learning system benefited from the novel presentation of keywords and associated context through the use of animations and adequate activities. The system performs well in terms of keeping the child engaged. Parents seemed pleased that the system knew when to repeat keywords that their child was struggling to comprehend, or had answered incorrectly when faced with a forced alternative. Parents gave positive responses also with regard to the manner in which keywords were repeated by the spaced repetition algorithm, a fact that confirms the system's utilization within special needs education in case of speech and language deficiencies.

In the future, additional research is required to expose more granularities in terms of difficulty of content and learning style. Some children find animation content too difficult, while others find it trivial. Some children prefer to learn through auditory or visual senses, while others in a more kinesthetic manner. It would be advantageous to be able to alter the difficulty and style of learning, in real time based on the child or therapists reaction to the current activity. This could be accomplished given sufficient time to develop animations laterally that worked in conjunction with the same keyword. For example, the system could attempt to deliver a keyword through complex animations, followed by a static image or simpler animation; speech accent could change the style and pace to allow for a different learning experience.

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