Understanding the Needs of Arab Learners with Dyslexia for Adaptive Systems

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Dyslexia is a universal reading difficulty independent of ethnicity or race. It is sensitive, though, to language and is affected by the language’s structure and orthography. Also, there are non-reading difficulties that co-occur with dyslexia, such as memory problems and low levels of self-esteem. Due to the lack of research in the Arabic language, this study aims to understand the needs of Arab learners with dyslexia in order to design adaptive interactive educational tools (IETs) based on their needs. To this end, the common reading and non-reading difficulties of learners with dyslexia and the features that the special education teachers (SPETs) prefer to either add or avoid when designing any IET, were explored in schools in Saudi Arabia, from the SPETs’ perspective. It was found that vowel letter dyslexia and visual dyslexia are the most common reading difficulties and that dictation difficulty and attention deficit are the most common non-reading difficulties. Hierarchical and Modelling teaching strategies are the teaching approaches that, from the SPETs’ perspective, most improved the reading of learners with dyslexia. Finally, pictures and sounds should be used in the design of IETs, while using many colours and loud sounds should be avoided.

1. INTRODUCTION

Dyslexia was identified more than one hundred years ago, in 1887. There have been many attempts to define dyslexia (Alsobhi, Khan and Rahanu 2014). However, it is best defined as a specific learning disability resulting from a neurological issue. It arises from a disorder in the language processing’s phonological component, resulting in various symptoms such as 1) inaccurate and/or slow word recognition 2) misspellings 3) poor decoding abilities (Lyon, Shaywitz and Shaywitz 2003) 4) word repetitions & additions and 5) eliminations & alterations during reading and writing (Tafft, Hameedy and Baghal 2009). Dyslexia is a universal reading difficulty independent of ethnicity or race. However, its manifestation is language dependent, affected by the structure and orthography (AlRowais, Wald and Wills 2013). In addition, there are a group of non-reading difficulties that co-occur with dyslexia. For instance, memory problems (Critchley 1968), depression, anxiety (Walker 2014) and low levels of self-esteem (Glazzard 2010). This study aims to understand the needs of Arab speaking learners with dyslexia, in order to inform the design of better adaptive IETs based on learners’ needs. This study was undertaken in schools in Saudi Arabia from the perspective of SPETs. The study explores: the common reading and non-reading difficulties of learners with dyslexia, the reasons that SPETs provide for the frequency of these difficulties, the technical features that these teachers prefer to either add or avoid when designing any IET, the SPETs’ justifications for their preferences and the teaching strategies that they prefer to have included in the design of such tools. A questionnaire was designed with a mixture of closed and open-ended questions. A mixed-methods approach, using qualitative and quantitative methods, was used to collect and analyze the data. The remainder of this paper is organized as follows. Section two presents the background upon which the study is built. Section three presents the research methodology, while section four presents the design of the study. Sections five & six present the collected data and discuss the results. Finally, section seven draws some conclusions and points to future work.
2. BACKGROUND

This section covers the theoretical foundation behind this work, dyslexia’s definition & difficulties, dyslexia in Arabic and the different interventions used for dyslexia.

2.1. Identifying Dyslexia and Difficulties

Dyslexia has been defined by the main international classification, ICD-10 (World Health Organization 1992), as “a specific and significant impairment in the development of reading skills, which is not solely accounted for by mental age, visual acuity problems or inadequate schooling”. Typical symptoms include inaccurate and/or slow word recognition or comprehension, misspelling and poor decoding abilities (World Health Organization 1992). Learners with dyslexia face a variety of difficulties:

(i) Reading difficulties, such as problems in identifying letters, migrating letters within a word or between words (Friedmann and Coltheart 2016).

(ii) Writing and spelling difficulties, such as slow writing or spelling errors (Walker 2014).

(iii) Social and behavioural difficulties, such as not participating and feeling shy or isolated (Critchley 1968; Glazzard 2010).

(iv) Other difficulties, such as short-term memory problems (Critchley 1968) and continuously calling for both help and reassurance (Glazzard 2010).

2.2. Dyslexia in Arabic

The manifestation of dyslexia is affected by language. The orthography and structure of any language has a large impact on the difficulties that the readers face. Unfortunately, there are few studies that explore dyslexia in Arabic. This study targets native Arabic speaking learners with dyslexia. Arabic is the fifth most spoken language. Over 200 million individuals speak Arabic as their first language. It is also used as a second language by millions of Muslims (Mahfoudhi, Everatt and Elbeheri 2011). The Arabic orthography is different from that of English. Therefore, the manifestation of dyslexia (AlRowais, Wald and Wills 2013) is different too (Elbeheri 2005). For instance:

(i) The cursive nature of the Arabic script (where the letters are joined to form a word or sub-word).

(ii) The use of dots to distinguish between similarly shaped letters.

(iii) Different letter forms based on the position within a word.

(iv) The use of non-vowelized text (Elbeheri 2005). Reading Arabic script without diacritics is a difficult process for beginners and poor readers (Abu-Rabia, Share and Mansour 2003). An equivalent in English would be to write each of “herd”, “hired”, “hard” and “heard” as “hrd”. This leaves the reader to use context to decode the word.

2.2.1. Types of Developmental Dyslexia in Arabic

There have been several attempts to classify dyslexia in order to better understand the difficulties and thus to provide better support (Alsobhi, Khan and Rahanu 2014; Friedmann and Coltheart 2016). One approach classifies dyslexia based on ‘symptoms’ (Ingram’s classification) (Alsobhi, Khan and Rahanu 2014) while another approach classifies dyslexia by using the dual-route model for single word reading (Friedmann and Coltheart 2016). This model helps to predict the different ‘symptoms’ of different types of dyslexia. It has proved effective and is widely used (Annett 1996). This is the classification that is adopted in this study. To understand the types of dyslexia based on the dual-route model for single word reading, understanding the reading process is essential (see Figure 1).

![Figure 1: Dual-route model for a single word reading (Friedmann and Coltheart 2016)](image-url)
word to its stem. For instance, decomposing the word "birds" into "bird".

(iii) If the target word is a known word (i.e. stored in the reader's lexicon), then the lexical-phonological route is used to read it quickly and accurately. This is achieved by passing that word to the orthographic input lexicon:
   (i) The phonological output lexicon will write to the phonemic output buffer.
   (ii) The corresponding entry in the conceptual-semantic system is activated to access the word's meaning.
(iv) If the target word is an unknown word, then the sub-lexical-phonological route is used by passing that word to the grapheme-to-phoneme conversion component. It analyses the word into either letters or groups of letters (graphemes) that form a single phoneme. Finally, this information is passed to the phonemic output buffer.

The previous stages illustrate the importance of each component of the dual-route model where each one performs an essential task in the reading process. Therefore, a deficit in any component will cause a reading difficulty and thus a type of dyslexia. Dyslexia in Arabic can be classified into seven types based on the deficit in the dual-route model: letter position dyslexia, attentional dyslexia, neglect dyslexia, visual dyslexia, surface dyslexia, vowel dyslexia and deep dyslexia (Friedmann and Haddad-Hanna 2014).

2.2.2. Dyslexia in Saudi Arabia
The Saudi government has prioritised education and provides services to all members of the society: adults and children. The government, also, focuses on the special education needs sector. To enhance the quality of the educational services for students with special education needs, the following steps were taken:

(i) Training SPETs.
(ii) Establishing regulations for Special Education Programs and Institutes which increased the range of disabilities to be included in the education system.
(iii) Introducing ‘Least Restrictive Environment’ terms to remove barriers towards learning.
(iv) Introducing Individual Education Plans to outline the individual needs and responsibilities. Approximately 5 percent of Saudi students are classified as having a Specific Learning Difficulty (SpLD) (Ministry of Education 2021), where LD is an umbrella for a wide range of disabilities, including dyslexia (Al-Shareef 2017).

2.3. Interventions for Dyslexia
A variety of interventions have been applied to reduce the long-term problems that learners with dyslexia face. There is school intervention, teacher intervention, workplace intervention, technological intervention and others. Providing accommodation for children with dyslexia is one approach of school intervention (for example not penalizing spelling errors or reading aloud assessment questions (Walker 2014)). Further, teachers provide a variety of interventions to learners, such as using an individualized plan (Beland and Mimouni 2001) or providing teaching strategies and techniques that suit their needs. Other teachers may focus on students' preferred learning styles (for example visuospatial/kinaesthetic learning (Exley 2003)). It is also argued that teaching strategies should be phonic and multi-sensory (Reid 2015). In other words, the teaching strategies should incorporate visual, auditory, kinaesthetic and tactile elements (Reid 2012). There are also some technological interventions available for learners with dyslexia. Some of these are adapted based on the different characteristics of the learner while others are not. In terms of non-adaptive e-learning systems, (Ouherrou et al. 2018) considered student motivation as one implication of a cognitivist approaches for e-learning systems. They developed an interactive learning game FunLexia to support children with dyslexia. However, only a very limited evaluation was undertaken. Another study, by (Aljojo et al. 2018), used a puzzle game-based system to assist children with dyslexia in correctly pronouncing Arabic letters. The children evaluated the system's usability in terms of learnability, efficiency, memorability, errors and satisfaction. Overall, the findings were not clear nor properly discussed. In terms of adaptivity, (Benmarrakchi et al. 2017) considered the learning style of learners with dyslexia as the learner characteristic for adapting e-learning. They developed an adaptive m-learning system to enhance fundamental skills such as reading, comprehension, writing, concentration, short-term memory and Arabic orthography. However, the method of evaluation was not presented and its effectiveness is unclear. Another study (Alghabban and Hendley 2020) considered the type of dyslexia as the learner characteristic. They investigated the impact of personalizing learning material (based on the type of dyslexia) on the learner's satisfaction with the system. A controlled experimental study was conducted to evaluate the system. The results showed that children with dyslexia were more engaged with their learning experience when the
learning content was adapted to their dyslexia type. However, the learning performance and effectiveness were not considered. Overall, there is very little research which draws upon an understanding of dyslexia from the perspective of teachers’ practice (especially from SPETs who interact directly with the learners) and which use this together with the theoretical literature to derive the design of adaptive learning. Therefore, this research seeks to understand the needs of Arab learners with dyslexia from the SPETs perspective and to link this with the literature to build an understanding. This understanding can then be used to design adaptive systems based on the learners’ needs.

3. METHOD

This study aims to understand the needs of Arab learners with dyslexia in order to design adaptive IETs based on learners’ needs. To do so, these needs were explored in schools in Saudi Arabia, from the SPETs’ perspective:

(i) The common reading and non-reading difficulties of learners with dyslexia and the reasons for their frequency.
(ii) The technical features that the SPETs prefer to either add or avoid when designing any IET and the justifications for their preferences.
(iii) The teaching strategies that the SPETs prefer to be included in the design of such tools.

Therefore, a questionnaire targeting SPETs was designed and published following the procedure below (see Figure 2):

(i) Design an initial version of a questionnaire.
(ii) Pilot the questionnaire with SPETs.
(iii) Publish the questionnaire (in the form of a MS Forms Link) to Saudi SPETs using different applications such as WhatsApp, Telegram and Twitter.
(iv) Chase the teachers to fill in the questionnaire.
(v) Collect data (SPETs responses).
(vi) Analyse data qualitatively and quantitatively.
(vii) Discuss the results and derive conclusions.

4. DESIGN

The design of the questionnaire followed three phases: initial version, pilot phase and final version. The aim of these phases is to validate the questionnaire and ensure that it is appropriate for SPETs. Each phase is detailed below.
4.2.2. Results
The results of the pilot phase are detailed below in terms of general comments and overall results.

**General comments:** Positive comments included: the questionnaire touched the field and was very detailed, perfect, complete, clear, can be answered and appropriate for everyone. The negative comments along with our comments are presented in Table 1.

**Table 1: SPETs’ Negative comments on the questionnaire**

| Negative Comments                                      | Researcher Comments                                                                 |
|--------------------------------------------------------|-------------------------------------------------------------------------------------|
| Some questions are similar (repeated). So, rephrasing could be an option. | The teacher maybe meant by similar questions the ones that were directed to native and non-native speakers. Also, the questions that provide some options and then ask the teacher to write their own answers. Rephrasing such questions is a good option. |
| A lot of questions to complete.                        | To collect information as much as possible.                                        |
| Merge each question with its “WHY” to decrease the length of the questionnaire. | Splitting such questions into two parts will force the SPET to answer both parts by providing two answer boxes. |
| Repeat some questions in a different form to check the reliability of answers. | This is a good practice but will increase the size of the task.                    |

**Overall Results:** 11 modifications were applied to the initial version of the questionnaire based on feedback (see Table 2).

**Table 2: Number of questions in the questionnaire affected after the pilot phase**

| Questionnaire Section | Deleted | Added | Rephased | Total |
|-----------------------|---------|-------|----------|-------|
| Demographic           | 0       | 0     | 0        | 0     |
| Dyslexia              | 1       | 1     | 6        | 8     |
| IET                   | 0       | 0     | 2        | 2     |
| Ending                | 0       | 1     | 0        | 1     |
| **Total**             | **11**  |       |          |       |

4.3. Final Version
The number of questions in the questionnaire increased to 41:

(i) **Demographic section:** this contains nine questions about the SPETs: academic level, gender, years of teaching experience, etc. This section helped in verifying that the person responding to the questionnaire is a SPET.

(ii) **Dyslexia section:** this contains 22 questions to determine: the common reading and non-reading difficulties that learners with dyslexia face.

(iii) **IET section:** this section contains nine general questions to identify any IET features that the SPETs prefer to include or avoid within the tool’s design.

(iv) **Ending section:** this gives the teachers the opportunity to add anything else they think is important.

5. DATA COLLECTION
The questionnaire was sent as a link to SPETs via WhatsApp, Telegram and Twitter. Two hundred and sixty-three participants opened the questionnaire. There were two filters to ensure that the questionnaire was answered by the target participants (SPETs who taught learners with dyslexia). These filters were “Are you a special education teacher?” and “During your teaching journey, have you ever encountered any TRUE dyslexic students?”. The first filter was used to identify whether the participant was a SPET. Only 157 participants were identified as SPETs. The second filter was used to identify those SPETs who have taught learners with dyslexia. Only 101 SPETs specified that they have taught learners with dyslexia. Therefore, 101 SPETs were included in the final analysis.

6. RESULTS
The questionnaire consisted of closed and open-ended questions. The closed questions such as multiple-choice questions were analysed statistically using SPSS. The open-ended questions were analysed manually using Thematic Content Analysis.

6.1. Common Reading Difficulties
The common reading difficulties were explored by listing four common reading difficulties plus an “other” option and giving the opportunity to add any other common reading difficulty they encountered with learners. The SPETs’ responses to the common reading difficulties list are given in Table 3. Vowel Letter Dyslexia is the most common reading difficulty, then Letter Position Dyslexia and finally Short Vowel Dyslexia. This is in line with (Friedmann and Haddad-Hanna 2014).
Table 3: Common Reading Difficulties From SPETs Perspective

| Common Reading Difficulties                  | Percent of Responses |
|----------------------------------------------|----------------------|
| Difficulty 1: Migrating the letters within the word that result to a known word. E.g. reading the word “Y'a'mal” as “Y'a'lam”. | 78.2%                |
| Difficulty 2: Migrating the letters within the word that result to a non-word. E.g. reading the word “Yahmel” as “Yamhel”. | 64.4%                |
| Difficulty 3: Mixing short vowels only. E.g. reading the word “kotob” as “katab”. | 69.3%                |
| Difficulty 4: Mixing between long and short vowels. E.g. reading the word “Katab” as “Kaateb”. | 84.2%                |
| Other Reading Difficulties.                  | 6.9%                 |

However, 6.9 percent of the SPETs chose the “other” option and added these reading difficulties:

(i) Reading letters separately without merging their phonemes to form the word.

(ii) Difficulty in spelling.

(iii) Mixing letter sounds.

(iv) Adding/substituting/deleting letters.

(v) Changing a word to a synonym: read by meaning.

(vi) Difficulty in reading syllables that have a Sakin letter.

In Saudi Arabia, male teachers teach male learners and female teachers teach females. Therefore, the SPETs’ responses were analysed taking into account their gender. The results for male and female SPETs were consistent. The same was found when considering the SPET’s location. The justifications were analysed, coded manually giving a total of 123 responses. Forty-six were discarded. The remaining 77 were categorized into: student (53.25 percent), reading (12.99 percent), teachers & teaching (15.58 percent), reading difficulty (10.39 percent), parents (5.19 percent) and other (2.60 percent). In terms of the student, some of the teachers’ justifications include developmental problems, genetic origin and academic neglect. Justifications in terms of the parent category include, a lack of reading, lack of parental interest and unwillingness to enrol their children into the LD program.

6.2. Common Non-Reading Difficulties

The common non-reading difficulties that co-occur with dyslexia were explored by listing 11 common non-reading difficulties plus an “other” option and giving the opportunity to add any other common non-reading difficulty they encountered with learners. The SPETs’ responses to the non-reading difficulties are given in Table 4. Dictation difficulty is the most common non-reading difficulty reported. This is in line with the literature in different languages (Knivsberg, Reichelt and Nødland 1999).

Their justifications were analysed and coded manually giving a total of 105 responses. Fifty-five of them were discarded leaving 50. 54
Table 4: Common Non-Reading Difficulties From SPETs Perspective

| Common Non-Reading Difficulties | Percent of Responses |
|---------------------------------|----------------------|
| Math Difficulty                 | 34.7%                |
| Writing Difficulty              | 52.5%                |
| Dictation Difficulty            | 87.1%                |
| Focus Loss                      | 53.5%                |
| Phonological Problems           | 14.9%                |
| Hyperactivity                   | 30.7%                |
| Vision Problems                 | 8.9%                 |
| Problems in differentiating     | 28.7%                |
| between directions              |                      |
| Remembering                     | 37.6%                |
| Memory problems                 | 45.5%                |
| Emotional/behavioural           | 28.7%                |
| (e.g. low self-esteem)          |                      |
| Other Non-Reading Difficulties  | 1.0%                 |

percent of these cited the relationship with reading difficulty or dyslexia. Other reasons cited included: parents refusing to enrol their children, academic neglect, developmental problems, lack of interest, inappropriate teaching strategies. Again, the SPETs were given the opportunity to mention any other common non-reading difficulties. The 101 responses were analysed, coded manually, giving a total of 224 separate responses. One hundred and seventy-two of them were discarded leaving 52. The most common (26.92 percent) was attention deficit. This is in line with (Willcutt et al. 2010). Again, they justified their choices of non-reading difficulties giving a total of 106 responses. Fifty-seven were discarded leaving 49. 36.73 percent of these responses cited the relationship with reading difficulty or dyslexia. Other reasons included students’ academic neglect, developmental problems, lack of interest, inappropriate teaching strategies etc.

6.3. Interactive Educational Tool

The SPETs’ opinions about using an IET as an aid for training rather than just using a textbook were obtained. Their answers are illustrated in Figure 3. 96.04 percent of them agreed that using an IET as an aid for training is better than just using a textbook.

These teachers justified their choice giving 127 separate responses. Eight of these were discarded decreasing the responses to 119. There was a variety of reasons related to different aspects; student (38.66 percent), IET (34.45 percent), reading skill (12.61 percent), curriculum (10.08 percent) and other (4.20 percent). In terms of student, most of the teachers argued that the IET attracts the student’s attention & focus and increases their motivation. There was also a variety of justifications related to IET itself. For instance, the IET is diverse, effective & interactive, simplifies the information and targets a specific problem. In terms of the reasons related to the reading skill, the teachers argued that the IET improves, encourages, helps and simplifies reading.

6.3.1. Technical Features

The IET section also explored the features that the SPETs think are useful in the design. Their choices are shown in Figure 4. The most useful features, from the SPETs’ perspective, are adding both audio and image to the design, (87.1 percent). This is in line with the cognitive theory of multimedia learning where five instructional design principles have been identified. For the multimedia aids, the material should be presented using both text and image while for the modality aids, the material should be presented as spoken text instead of onscreen text (Mayer and Moreno 2002). It is also recommended by (Benmarrakchi, Kafi and Elhore 2017) to use the multisensory approach since learners with dyslexia prefer the visuospatial/kinesthetic style (Exley 2003). The least useful features were using points and a progress bar which was chosen by only 31.7 percent. However, this contradicts (Dymora and Niemiec 2019) where points are considered to be one of the main elements for motivating users. In addition, the SPETs were able to suggest any other useful features not listed in Figure 4. Their responses were analysed and coded manually giving a total of 154 responses. Seventy-eight of them were discarded. 71.05 percent of the remaining 76 responses were features related to the educational tool’s interface or functionality and 28.95 percent were features related to the students. In terms of interface, a majority have suggested the use of colours and special/cartoon characters. In terms of functionality, a majority suggested to include direct and automatic correction. However, 86.36 percent of the responses targeting students were directed
to student’s emotions. For instance, they suggested the educational tool to be attractive, encouraging, motivating and engaging.

![Figure 4: IET Features Preferred to be Included](image)

The teachers justified their choices in 111 responses. Forty of them were discarded. The remaining responses were analysed and coded manually into: teacher experience, reading, student, IET features, memory and other. 60.56 percent of the responses targeted the student, especially their emotions (62.79 percent). In other words, the teachers chose the previous IET features to attract students' attention. The feature’s effectiveness was the dominant justification. After analysis, the justifications were related to: colours, large font, interaction, feedback and modelling strategy. The negative features that the SPETs prefer to avoid were also explored. Their responses were analysed and coded manually giving a total of 180 responses. Forty-six of them were discarded. Most of the remaining responses targeted colour, image, audio and other features. 22.40 percent were related to colours, 12.80 percent were related to images/pictures and 12 percent to audio/sound. In terms of colours, most teachers suggested to avoid using many colours and annoying/unclear ones. In terms of images, they suggested to avoid using many and distracting images while in terms of audio, they suggested to avoid using loud and distracting sounds. There were a variety of different responses that were included in the “other IET features” category such as avoiding long learning periods, distraction, small fonts and complexity. In other words, the design of IET should avoid any distracting surroundings as identified by the British Dyslexia Association (BDA 2018). Finally, the teachers justified their decisions in 123 responses (after coding and analysing). Twenty-five of these responses were discarded leaving 98. The majority targeted the student, especially their emotions (73.24 percent). The teachers suggested to avoid features in order to: avoid distracting students, simplify their reading, increasing their vocabulary and helping them to read. Avoiding complexity and focusing on the goal to be achieved, were other examples.

6.3.2. Teaching Strategies

Finally, the SPETs were given the opportunity to suggest teaching strategies they would prefer to be embedded in any educational tool. Their responses were analysed and coded manually giving a total of 171 responses. Eighty-seven responses were discarded. The remaining 84 responses identified 30 different teaching strategies. The top five are Repetition (14.29 percent), Learn by play (11.90 percent), Modelling (10.71 percent), Multisensory (9.52 percent) and Word Analysis (5.95 percent). Then, the teachers' justifications were also analysed and coded manually, giving 119 responses. Thirty-four of them were discarded. The majority of the remaining 85 responses targeted the student and the teaching strategy. In terms of student, the teachers suggested teaching strategies to increase the student's motivation and attract their attention. In terms of teaching strategies, the justifications included that they were beneficial, effective, simplify reading and because of previous good results.

7. CONCLUSION AND FUTURE WORK

Dyslexia is a reading difficulty that exists everywhere regardless of ethnicity or language. However, it is a language dependent difficulty that is affected by the language’s structure and orthography which in turn affects the manifestation of dyslexia. There are a group of reading and non-reading difficulties faced by learners with dyslexia. Problems in identifying letters and migrating letters within words or between words (Friedmann and Coltheart 2016) are examples of reading difficulties, while short-term memory problems (Critchley 1968) and calling for both help and reassurance (Glazzard 2010) are examples of non-reading ones. This study aimed to understand the needs of Arab learners with dyslexia to inform the design of adaptive IETs based on the students' individual needs. These were explored in Saudi Arabia schools from the SPETs’ perspective to identify:

(i) Common reading and non-reading difficulties of learners with dyslexia.

(ii) Reasons for their frequency.

(iii) Features that SPETs prefer to add or avoid in the design of IETs.

A questionnaire was designed with a mixture of closed and open-ended questions. The questionnaire was piloted to guarantee its validity and reliability. It was published to SPETs on-line. A mixed-methods approach was used to collect and analyse the 101 responses. The quantitative data was analysed using SPSS while the qualitative data was analysed and coded manually using the Thematic
Content Analysis approach. Several findings based on the SPETs’ perspective were revealed:

(i) Vowel Letter Dyslexia and Visual Dyslexia were the common reading difficulties encountered by SPETs.

(ii) Dictation difficulty and attention deficit were the common non-reading difficulties encountered by SPETs.

(iii) They preferred to see both audio and visual features embedded in the IET design, while points and progress bars were seen as the least useful.

(iv) Using many colours, images or distracting sounds were the features they suggested as ones to be avoided.

(v) Several teaching strategies can improve the reading of learners.

The purpose of this study was to build an understanding of current experience, practice and opinions of SPETs. The results can guide future research and development in several ways:

(i) Identifying important user attributes (e.g. dyslexia type, motivation, attention), successful teaching strategies, important interaction issues, important metrics when evaluating these system and so on.

(ii) Informing the design of adaptive systems for teaching learners with dyslexia: by determining the features that should be represented in the learner model and then determining the appropriate adaptation strategies.

(iii) Building an additional set of design guidelines that can augment the existing guidelines for system developers. These can then drive the design of the learning and, for instance, the use gamification elements.

(iv) Highlighting the importance of empirical evaluation of these systems, with the targeted learners, in order to understand both their usability and their learning effectiveness.

The longer-term aim of this work is to combine this practice-based understanding with the theory driven approaches to design, build and evaluate adaptive interventions to support the learning of learners with dyslexia. In the future, an IET will be designed collaboratively with SPETs, for example targeting Vowel Letter Dyslexia or Visual Dyslexia and including images and audio or including the suggested teaching strategies. The tool will be evaluated empirically with learners with dyslexia.

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