A RESEARCH REVIEW: HOW TECHNOLOGY HELPS TO IMPROVE THE LEARNING PROCESS OF LEARNERS WITH DYSLEXIA

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This project is submitted
in partial fulfilment of the requirements for a
Bachelor of Science with Honours
(Cognitive Science)

Faculty of Cognitive Sciences and Human Development
UNIVERSITI MALAYSIA SARAWAK
(2015)

The project entitled 'A research review: How technology helps to improve the learning process of learners with dyslexia' was prepared by Chai Jing Ting and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Sciences)

Received for examination by:

_____
(Assoc. Prof. Dr. Chen Chwen Jen)

Date:
9th June 2015
_____

| **Grade** |
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ACKNOWLEDGEMENTS

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ABSTRACT

Dyslexia is a language disorder that leads to difficulty with words and it is the most common type of learning disability. This study is a systematic review on the current state of technologies used in improving the learning process of learners with dyslexia. A total of twenty-five journals articles and international conference papers published between 2000 and 2014 were included in the review. The research articles were collected from twelve databases and being analyzed according to cyclical process. The findings show that majority of the studies focused on children and adolescents. There are four main research themes derived and discussed for the technologies used in the learning process of learners with dyslexia, namely, text-to-speech technologies, eye-tracking technologies, virtual learning environments, and games. Additionally, there are another four main research themes revolve around the purpose of the assistive technologies, namely, reading, writing, memory, and mathematics. Furthermore, text-to-speech technology is the most common technology used by learners with dyslexia. Moreover, a majority of the studies mention and focus the use of technologies on the improvement of reading in learners with dyslexia. This study is expected to provide a clearer view on the current state of technologies used in improving the learning process of learners with dyslexia.

Keywords: assistive technology, technology, dyslexia, learners with dyslexia

ABSTRAK

Disleksia adalah gangguan bahasa yang menyebabkan kesukaran untuk menggunakan perkataan dan ia merupakan salah satu jenis masalah pembelajaran yang paling biasa ditemui. Kajian ini adalah satu ulasan sistematik tentang bagaimana teknologi meningkatkan proses pembelajaran pelajar disleksia. Seramai dua puluh lima jurnal artikel dan kertas persidangan antarabangsa yang diterbitkan dari tahun 2000 hingga 2014 termasuk dalam kajian ini. Artikel-artikel penyelidikan dikumpulkan dari dua belas pangkalan data dan dianalisis dengan mengikut proses kitaran. Hasil kajian menunjukkan bahawa majoriti daripada kajian memberi tumpuan kepada kanak-kanak dan remaja. Selain itu, terdapat empat tema penyelidikan utama yang diperolehi dan dibincangkan dengan berdasarkan tujuan dan teknologi yang digunakan dalam proses pembelajaran pelajar disleksia. Tambahan pula, teknologi "text-to-speech" merupakan teknologi yang paling kerap atau biasa didunakan dalam kalangan pelajar disleksia. Selain itu, kebanyakan kajian yang didapati memberi tumpuan pada penggunaan teknologi untuk meningkatkan kemahiran membaca dalam kalangan pelajar disleksia. Kajian ini diharapkan dapat memberikan gambaran yang lebih jelas mengenai keadaan semasa tentang teknologi yang digunakan dalam proses meningkatkan pembelajaran pelajar disleksia.

CHAPTER ONE

INTRODUCTION

"Learning disabilities are neurological disorders that can make it difficult to acquire certain academic and social skills" (National Center for Learning Disabilities, 2014b). It is reported that there are over one billion people in this world live with disabilities and about 150 million of them are school-aged students (Laabidi, Jemni, Ayed, Brahim, & Jemaa, 2013). According to National Center for Learning Disabilities (2014b), there are four main types of learning disabilities, which are Dyslexia, Dyscalculia, Dysgraphia and Dyspraxia. Dyslexia is one of the most common learning disabilities (Saviour, Padakannaya, Nishanimutt, & Ramacahndra, 2009). Learners with dyslexia often have difficulties to perform accurate word recognition, decoding, reading, spelling, speaking and writing (Lapkin, 2014).

In this era of globalization, the use of information and communication technologies (ICTs) assisted learning has increased significantly, including for learners with learning disabilities. More than a decade ago, it is estimated that less than ten percent of children with learning disabilities do not receive any education in developing countries (Florian, 2003). Florian (2003) further asserts that even in developed countries, policies that call for greater involvement of students with special education needs in education seen to conflict with other education policies that emphasis on high achievement. However, in a report by Nolan, Gleeson, Treanor, and Madigan (2004), the number of students with disabilities accessing Higher Education Institutions (HEIs), including professional courses has increased significantly from year to year. The rapid advancement of technologies most probably explain this change as technologies have provide opportunities and help the students with learning disabilities to overcome the obstacles they met in traditional education systems.

Many articles have been published on the development of technologies to assist persons with learning disabilities, and several reviews of the literature have been completed

within the last few years. However, a review of the compilation of 25 articles (Rello &
Baeza-Yates, 2014; Rello, Bayarri, Otal, & Pielot, 2014; Schiavo & Buson, 2014; Ahmad,
Jinon, & Rosmani, 2013; Al-Edaily, Al-Wabil, & Al-Ohali, 2013; Malekian & Askari, 2013;
Moe & Wright, 2013; Ndombo, Ojo, & Osunmakinde, 2013; Rekha, Gollapudi, Sampath, &
Indurkhya, 2013; Habib et al., 2012; Hornickel, Zecker, Bradlow, & Kraus, 2012; Kalyvioti
& Mikropoulos, 2012; Rello, Kanvinde, & Baeza-Yates, 2012; Chang & Liu, 2011; Khakhar
& Madhvanath, 2010; Abdullah, Hisham, & Parumo, 2009; Diraa, Engelen, Ghesquire, &
Neyens, 2009; Ecalle, Magnan, Bouchafa, & Gombert, 2008; Freda, Pagliara, Ferraro,
Zanfardino, & Pepino, 2008; Tzouveli, Schmidt, Schneider, Symvonis, & Kollias, 2008;
Draffan, Evans, & Blenkhorn, 2007; Dziorny, 2007; Arendal & Brandt, 2005; Nelson &
Parker, 2004; Dranffan, 2001) from electronic databases such as Science Direct, Wiley
Online Library, Academic Search Premier and Google Scholar has shown that most articles
focus on assistive technologies for different types of disabilities. This review focuses on the
current state of research on how technologies help the learning process of students with
disability especially learners with dyslexia.

Background of the study

The basic concepts of dyslexia and assistive technologies will be presented in this
section. Dyslexia is a language learning disorder that leads to difficulties in reading, spelling
and phonological (Oakland, Black, Stanford, Nussbaum, & Balise, 1998). It is neurological
disorders and often caused by genetic (Chan, Foss, & Poisner, 2009). According to Rahmani
(2011), four percent of the population is estimated as dyslexic and another six percent have
mild to moderate dyslexic. Basically, according to National Center for Learning Disabilities
(2014b), there are some common warning signs of dyslexia in different stages (pre-
kindergarten to kindergarten, primary to secondary school and college or university). The
common warning signs of dyslexia in the first two stages are similar, which are delayed

learning to speak, read, and write at an appropriate level and not motivated and self-confident about learning. On the other hand, the common warning signs of dyslexia in college or university including failed to understand non-literal language, express ideas clearly, read aloud with fluency and accuracy, use proper grammar, and perform consistently from day to day.

Assistive technology is the technology used by people with disability in order to build on individual strengths, compensate for their disabilities and improve their performance (Lewis, 1998). Implementation of assistive technology enables learners with dyslexia to complete tasks independently and efficiently and results in the improvement of academic achievement. There are specific adjustment software or devices for manipulating the computer in order to enable users to access the content on screen, command the computer and process the data (Laabidi et al., 2013). As mentioned by Laabidi et al. (2013), the specific adjustment software or devices are screen reading software, screen magnification software, braille display, alternate input devices and special keyboard, keyboard enhancements and accelerators, and alternative pointing devices.

There are several related reviews have been completed within the last few years. Laabidi et al. (2013) have conducted a research towards the development of an accessible online learning environment for people with disabilities. In the paper, they have covered the basic concept of assistive technology and focused on accessible e-learning system. Besides that, a review on the development of assistive technology specific assessment models and instruments for children with multiple disabilities has been done by Desideri, Roentgen, Hoogerwerf, and Witte in 2013. Furthermore, Starcic and Bagon (2014) have executed a review on ICT-supported learning for inclusion of people with special needs.

Problem statements

Generally, disabilities or special needs can be defined in different ways. In the recent review of Laabidi et al. on learning technologies for people with disabilities, they have focused and grouped disabilities according to the type of impairment. According to Laabidi et al. (2014), disabilities can be divided into four groups which are mobility impairments, visual impairments, hearing impairments and cognitive impairments. On the other hand, Desideri et al. conducted a systematic review on assistive technology models and instruments and their targeted group for the review is children with multiple disabilities. In the research paper, children with multiple disabilities are grouped by any combination of concomitant impairments such as neuromuscular dysfunction, cognitive and intellectual disabilities and other physical and sensory impairment (Cass, Price, Reilly, Wisbeach, & McConachie, 1999). Furthermore, in the review of Starcic and Bagon (2014) on ICT-supported learning for people with special needs, they have labeled many groups as those with special needs. For example, they have considered hearing impairment, visual impairment, handicapped, learning disability etc. as special needs. The existing reviews seem to place focus on assistive technologies for different types of disabilities or special needs and to the researcher's knowledge, lack of such major reviews focus specifically on dyslexia while according to Saviour et al. (2009), dyslexia is the most common type of learning disability.

Purpose

The purposes of this study are:

- To explore the current state of research on how technology helps to improve the learning process of learners with dyslexia.

Objective

The objectives of this study are:

- To identify studies those are related to the use of technology to improve the learning process of learners with dyslexia.

- To analyze these identified studies and derive main research themes investigated in the current body of literature.

- To identify technologies that help to improve the learning process of learners with dyslexia.

Research questions

The research questions of this study are:

- What are the studies those are related to the use of technology to improve the learning process of learners with dyslexia?

- How to analyze these identified studies and derive main research themes investigated in the current body of literature?

- What are the technologies that help to improve the learning process of learners with dyslexia?

Definition of terms

Dyslexia

Dyslexia is a type of learning disabilities. It is the difficulties with language caused by genetic brain difference and the difficulties including spelling, reading, writing and speaking (Merkle, 2014).

Assistive technology

Assistive technology is defined as the software and technology that helps disabled people to overcome the additional challenges they face in communication and learning (British Educational Communications and Technology Agency, 2003).

Significance of the study

This study provides a clearer view on the current state of technology used in improving learning process of learners with dyslexia. Currently, the technology available such as assistive technology provides accessibility for learners with dyslexia to overcome additional challengers and improve their performance independently. On the other hand, this study will increase the awareness of readers and keep readers up to date on suitable types of technologies used for learners with dyslexia. For an example, text-to-speech system is popularly used by learners with dyslexia in learning by converting text held on a computer system to synthesized speech. Besides that, this study delivers further information on dyslexia to readers and increases the understanding of readers on dyslexia.

Scope of the study

The scope of study is the online articles and research papers that focus on technologies used in reinforcing the learning process for students with learning disabilities (specifically dyslexia) from year 2000 to 2014. The electronic databases used for data collection were ACM Digital Library, Google Scholar, IEEE Xplore Digital Library, Springer, Elsevier, Emerald Insight, Wiley Online Library, National Academy of Sciences (NAS), Taylor & Francis Group, informa healthcare, EdITLib, and The Higher Education Academy Journals.

CHAPTER TWO

LITERATURE REVIEW

Dyslexia

Dyslexia is a word that originated in the Greece. According to British Dyslexia Association (BDA) (2013), dyslexia is defined as the difficulty with words. Specifically, the term is coined from the prefix "dys", which means difficulty and the root word "lexia", which means language. Dyslexia is caused by a defect in the brain's ability to transform images received from the eyes and sound from the ears into an understandable form (Wan & Uda, 2014). Dyslexia is usually hereditary (Chan, Foss, & Poisner, 2009). Finding of the research indicates that males are having higher probability to have dyslexia than women and patients who are diagnosed with dyslexia are comprised of mainly students (Tinklin, Riddell, & Wilson, 2005). Recently, researchers have reported that the number of males to have dyslexia is three times higher than females (Rahmani, 2011). According to Alsobhi and Abeysinghe (2013), dyslexia can be generally classified into three categories which are visuo-spatial difficulties, speech sound difficulties and correlating difficulties. Persons with visuo-spatial difficulties have problems in recognizing groups of letters. They will try to guess words by their shapes but not by context. Besides that, persons with speech sound difficulties have problems in understanding spoken language whereas those with correlating difficulties have problems in finding the appropriate speech sounds for individual letter or sounds in writing.

Besides the most noticeable symptom of dyslexia which is difficulty with text, either reading or writing, dyslexia also affects the way information is processed, stored and retrieved, with problems of memory, speed of processing, time perception, organization and sequencing (British Dyslexia Association, 2012). Dyslexia affects people in different ways (Alsobhi & Abeysinghe, 2013). It also means that two people will rarely have the same symptoms of dyslexia (British Dyslexia Association, 2013). It is quite impossible to make

generalizations when designing the module material prior to the start of learning period because the types of difficulties and needs of learners with dyslexia may vary from one student to another. However, according to British Dyslexia Association (2013), learners with dyslexia can learn effectively but often need a different approach.

Assistive technology

Assistive technology can be defined in different ways. British Educational Communications and Technology Agency (Becta) defines assistive technology as "the software and technology which helps people with disabilities and special needs to overcome the additional challengers they face in communication and learning" (Becta, 2003). Foundation of Assistive Technology (FAST) defines it in a way as "assistive technology is any product or service designed to enable independence for disabled and older people" (FAST, 2001). According to FAST (2001), United States is the only country in the world with statutory legislation relates to the acquisition of assistive technology and a legal definition of assistive technology. The Assistive Technology Act of 1998 defines the term 'assistive technology device' as " any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities" (FAST, 2001). Generally, assistive technology is the technology design especially for people with disabilities and to improve their performance independently in different aspects.

As mentioned before, assistive technology is intended to help people with disabilities in different ways. There are two general approaches used to address the difficulties faced by individuals with learning disabilities, which are remedial approach and compensatory approach (National Center for Learning Disabilities, 2014a). Remedial approach helps to alleviate a specific deficit or improve an area of weakness whereas compensatory approach aids to accommodate or bypass a deficit. For an example, if a child has a problem on reading,

remedial approach might focus on how to improve the reading skills while compensatory approach might provide materials such as text-to-speech software to enable the child hear the text spoken clearly. On the other hand, the appropriateness of remedial technologies is depending on the type of the disability being supported (McKnight & Davies, 2012). Raskind (1994) suggested that compensatory approach may be more appropriate for adults with learning disabilities as compared to remedial approach. Raskind further explained that adults with learning disabilities always require immediate solutions rather than receive remedial training and improve their skills. Compensatory approach is said to be a better choice for adult with learning disabilities since it offers a more immediate solution to a particular problem.

Related findings on assistive technology towards people with disabilities

Draffan, Evans and Blenkhorn (2007) have conducted a research on the use of assistive technology by learners with dyslexia. A wide variety of computer-related hardware and software is supplied to learners with dyslexia and it can be classified into four areas which are general-purpose hardware, special-purpose hardware, general-purpose software and special-purpose software (Draffan, Evans, & Blenkhorn, 2007). Assistive technology is applied in the special-purpose software. The most commonly used special-purpose software by learners with dyslexia are text-to-speech systems, CD-based talking dictionaries, concept mapping software and word prediction and word banks (Draffan et al., 2007). Text-to-speech systems are the systems that convert text held on a computer system to synthesized speech. According to Fidler's finding, most of the learners with dyslexia used text-to-speech system (TextHelp) for proof reading, spell checking, reading texts and grammar checking (Fidler, 2002). CD-based talking dictionaries provide speech output from standard dictionary and the speech produced by talking dictionaries is recorded human speech (Draffan et al., 2007). Besides that, concept mapping software is used by learners with dyslexia to organize

information. A concept mapping software can be said to be a very powerful and concise knowledge representation tool (Novak & Canas, 2006). It also enables learners with dyslexia to see the big picture of the information given and understand the overall presentation of information. On the other hand, word prediction and word banks help learners with dyslexia in typing and word selection (Draffan et al., 2007).

In the review paper done by Starcic and Bagon (2014), they focused on information and communication technology (ICT)-supported learning instead of assistive technology. The main finding of the review indicated that majority of the papers published focused on specific disability groups or multiple disabilities, and most paper published on learning disabilities. From the content analysis, ICT interventions were classified into two categories, technical intervention in the pedagogical context and technical intervention in the wider context. The significant of ICT-assisted learning is increasing in formal educational settings, in non-formal settings and in general support for life (Starcic & Bagon, 2014). Starcic and Bagon further explained that ICT provides accessibility and equal engagement and facilitates overcoming of potential isolation by connecting students with disabilities to social environments and encouraging them to participate in education and wider society. Besides that, there are few papers from the review address universal design. Student with different accessibility requirements need the possibility of equal engagement in learning environment. Hence, universal design principles could make a significant contribution to the support of inclusion processes and provide accessibility of resources (Starcic & Bagon, 2014).

In the review of Laabidi et al. (2013), they have briefly discussed on e-accessibility, universal design, assistive technology and special focus on accessible e-learning systems. They have presented their recent research work on the development of an assessible online learning environment for people with disabilities from the design and specification step to the implementation. According to Sampson and Zervas (2011), accessibility has been recognized

as a key design consideration for technology-enhanced e-inclusion of people with disabilities. Laabidi et al. have elaborated meta-model for assessable e-Learning systems and it helps to provide an accessible content for the generation, the conformance of the content to e-Learning and accessible properties as well as the transformation into an implementation adapted to specific needs.

In Desideri, Roentgen, Hoogerwerf and Witte (2013) review on qualitative synthesis of models and instruments for assistive technology professionals, they limit their scope to children with multiple disabilities. The review paper discussed that assessing children with multiple disabilities is a complex process which involves several tasks. Regarding which instruments are suitable for children with multiple disabilities, Copley and Ziviani (2005) concluded that in comparison with the tools developed within the Technology Team Assessment Process (TTAP) model, Lifespace Access Profile (LAP) and Lifespace Access Profile: Upper Extension (LAPUE) assessment tools better satisfy the criteria making for assistive technology recommendations for children with multiple disabilities. LAP was developed for people with severe and multiple disabilities while LAPUE was intended for use with people with physical disabilities but do not have cognitive impairments. Both assessment tools provide a structure for the educational team to collect data on all the aspects of the individual and the environment with the use of assistive technology (Copley & Ziviani, 2005). The purpose of the assessments is to bring together the different perspectives and ideas from team members in order to identify how assistive technology can benefit the child and then to develop assistive technology solutions.

In conclusion, the existing reviews discussed on assistive technology and most of them focused on specific type of assistive technology such as information and communication supported learning. Besides that, most of the reviews place focuses on people with learning disabilities or multiple disabilities rather than dyslexia. On the other hand,

universal design is a key design consideration in designing an assistive tool since individuals with disabilities require different needs in accessing the tool. A well designed assistive technology (tool) provides accessibility and equal engagement for people with disabilities and hence, it helps to overcome additional challengers and improve their performance independently.

CHAPTER THREE

RESEARCH METHOD

Research design

This study used systematic review as the research methodology. A systematic review always present a comprehensive review of the literature based on the best available with regard to a specific question (The Campbell Collaboration, 2014). This review research is designed to focus on how technology helps to improve the learning process on learners with dyslexia. Several existing studies (Starcic & Bagon, 2014; Laabidi et al., 2013; Desideri et al., 2013) focus on learning disabilities rather than dyslexia. First of all, the need for a review (questions) was identified. After that, a proposal for the review was prepared. Next, the sample of the research that is the relevant research articles were searched from the electronic databases. The time-frame encompassed by the search was from 2000 to 2014. Besides that, a list of search terms such as assistive technology and dyslexia was used for the data searching. Data analysis was carried out after the data collection completed. There are four steps in data analysis which are reading or memoing, describing, classifying and interpreting the data collected. The data was analyzed into different themes and presented in a table form. Finally, the result was discussed in details and a conclusion was drawn according to the findings.

Sample and population

The research articles involved in this review were scientific journals and proceeding of international conferences from electronic databases. A total of 100 journals and international conferences papers published between 2000 and 2014 were included in the review.

The population of this research was research studies published as full length articles written in English between 2000 and 2014. The relevant literature reviewed or research articles were found through the electronic databases of academic resources. The databases

used for data collection were ACM Digital Library, Google Scholar, IEEE Xplore Digital Library, Springer, Elsevier, Emerald Insight, Wiley Online Library, National Academy of Sciences (NAS), Taylor & Francis Group, informa healthcare, EdITLib, and The Higher Education Academy Journals.

Data collection procedures

In the data collection process, inclusion and exclusion criteria was consistently applied throughout the process. A list of search terms were used in the searching process, for example, "assistive tools", "assistive technology", "type of assistive technology", "learning process of dyslexic students", "dyslexia", "learners with dyslexia", "people with dyslexia" and "person with dyslexia". The search terms were combined by mean of Boolean logical operator 'AND' in order to decrease the scope and reduce the number of non-pertinent results. There are three steps involved in the searching process. First, the titles of the papers retrieved were reviewed. The articles with unrelated terms such as physical disabilities were excluded for consideration. After that, the abstracts of the selected papers were read. The criterion for inclusion before proceed to next step is that the articles must include specific characteristics such as assistive technology or dyslexia. Finally, the selected articles were read in full and analyzed.
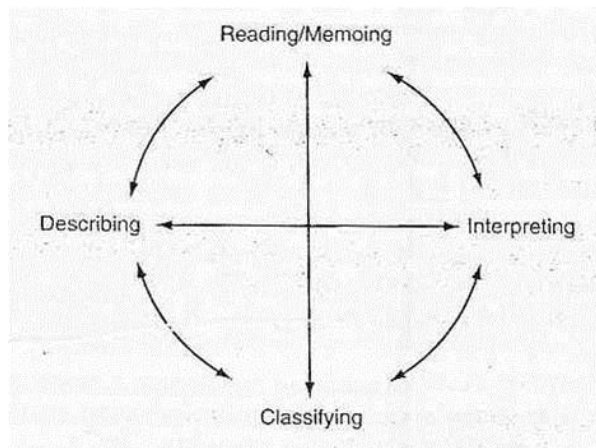
Data analysis techniques

Figure 1. Cyclical process

After the data collection process, the data collected were managed and labeled according to the data type. The data analysis technique used was a cyclical process (as refer to *Figure 1*) based on qualitative research. It is a non-linear process. In other words, the process is not necessary to be followed exactly step by step and the steps can be repeated more than once throughout the analyzing process. Cyclical process involves four main steps which are reading or memoing, describing, classifying and interpreting. During the reading and memoing step, all the data collected were read in detail and the important sections were highlighted. If there were some extra thoughts or important notes, memos were written down. This step is important in identifying potential themes from the data collected. During the describing step, the data collected were examined in depth and described. Next, in the classifying step, the data will be broken into smaller units and the similar concepts were organized into a theme. Finally, during the interpreting step, the dissimilarities between the findings of studies are investigated and interpreted.

CHAPTER FOUR

FINDINGS AND DISCUSSION

Data Collection

A total of 25 journal articles and international conference papers published between 2000 and 2014 were included in the review. The relevant journal articles and international conference papers were found through the electronic databases of academic resources. The databases used for the data collection are ACM Digital Library (3 papers), Google Scholar (3 papers), IEEE Xplore Digital Library (3 papers), Springer (5 papers), Elsevier (3 papers), Emerald Insight (1 paper), Wiley Online Library (2 papers), National Academy of Sciences (NAS) (1 paper), Taylor & Francis Group (1 paper), informa healthcare (1 paper), EdITLib (1 paper), and The Higher Education Academy Journals (1 paper).

Table 1
Analysis of data

Study, Database used	Methodology	Target population considered	Participants	Age ranged/ targeted	Technology used/ involved	Purposes
Rello & Baeza-Yates (2014) ACM Digital Library	Experimental research -online questionnaire -semi-structured interview	_	Target group: 32 participants with dyslexia (18 female and 14 male) Control group: 38 participants without dyslexia (24 female and 14 male) Usability evaluation: 12 participants with dyslexia (3 female and 9 male)	6 to 52 years old (mean = 23.15 years)	DysWebxia -CASSA (Context Aware Synonym Simplification Algorithms)	Reading -improve the reading performance -provide suitable and simpler synonyms for complex words
Rello, Bayarri, Otal, & Pielot (2014) ACM Digital Library	Quantitative research -questionnaire -one pre-tests and two post-tests	54 potential participants with literacy difficulties	48 children with dyslexia (29 girls and 19 boys)	6 to 11 years old (mean = 8.79 years)	DysEggxia (game designed to support the spelling acquisition)	Writing -improve spelling skills -reduce spelling errors
Schiavo & Buson (2014) Google Scholar	Empirical research	Learners (readers) with dyslexia	_	_	Interactive e-books	Reading -improve in memorizing and practicing word pronunciation -improve phonemic awareness