Educational Software for Dyslexic Children : A Systematic Literature Review

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Abstract:
Educational software nowadays gives something beneficial to the users, especially to the student. Many features in the educational software can help students to learn more and are exciting to do the task. This paper presents how game features are used for dyslexic children in mobile game applications. The purpose of this literature review is to explore the methodology used in research related to educational software for dyslexic children. This methodology used in this paper is adapted from Kencheman and Keele and Petterson.The results show that most of the literature used quantitative methodology in their research. In addition, the studies were more focused on children rather than adult respondents. The literature suggests several software design guidelines for dyslexic children. Most of the educational software discussed in the literature are games, mobile applications and couseware. Findings supported that the use of the application to educate and develop children skills in learning is vital for dyslexic children.

Keywords: Educational software, SLR, dyslexic children, game learning

1. Introduction

Dyslexic children are exposed to different learning disabilities, such as dyslexia, dysgraphia, and dyscalculia (Anoual & Lakhouaja, 2018). Those disabilities will have a negative impact on the academic achievement of the child because of learning difficulties which leads to frustration (Rauschenberger et al., 2019) until the child is diagnosed. However, there are many tools that can help dyslexic children to learn and nourish their potential to be a successful person one day.

Games based is one of helpful tools to teach dyslexic children in an exciting and fun way(Sholdova, 2020a). Applications in smartphones are a powerful tool that can help children with dyslexia to motivate and facilitate them (Khan et al., 2018). Digital games can become a form of educational intervention that can positively give a big influence to active learners and motivate them to participate actively in the classroom. These games are deemed as an effective tool which could encourage learning among digital natives (Ghani et al., 2019)

In the last few years, the use of technologies in education has been used to interact with students. Fun-guided learners are more easily motivated to continue the learning process by fulfilling meaningful activities and or tasks that are defined in the context of the game dyslexia (Sholdova, 2020b). Educational technologies in the form of handheld devices endeavour to complete the traditional forms of teaching using blackboard and chalks (Anoual & Lakhouaja, 2018). These technologies will help students in education to learn in a fun way.

2. Methodology

To carry out this review, the researchers followed the recommendations by Kitchenham (Kitchenham, 2004), Keele (Keele, 2007) and Petersen (Petersen et al., n.d.) to use the qualitative systematic review process in order to identify the themes and issues highlighted about the use of educational software or application fo dyslexic children. In this section, the planning of the review is explained and the details of the review method are explained below. The details include the research questions, inclusion criteria, data sources and search strategy.

Specifically, the steps followed for the development of the literature review were the following:

A. Planning the review
1. Ask the question and sub-questions of the review
2. Definition of preliminary categories of analysis

B. Search
3. Define the sources of literature search
4. Define the inclusion and exclusion criteria of the literature
5. Define the search criteria
6. Search of literature
7. Selection of literature

C. Analysis of literature
8. Reading of the selected literature
9. Data extraction and coding

D. Results report
10. Interpretation of results
11. Generation of the review report

In the following sections, each of the steps followed for the review is described in detail.

2.1 Research Questions

The main research question that this literature review addresses are:

I. What are the methodology used in research related to educational software for dylexic Children?

II. What are education software design criteria that are suitable for dylexic children?

III. What was the platform used to deliver learning for dylexic children?

2.2. Search Strategy

It can see through strategy where it involves two phases that are primary and secondary search. Google scholar was the primary search which involved the famous online databases that contain scientific articles and journals, conference proceedings and technical papers and for the secondary search is Google search engine where it involved a thorough review of the references and citations. The search terms used that matched with the logical word such as "Educational design","Educational design AND "educational dyslexia"

2.3 Inclusion and exclusion criteria

The articles were sampled according to the identified inclusion criteria.

The inclusion criteria are:
1.   Include the paper that was published between 2017 to 2021.
2.   Studies that describe interface design/educational software for dyslexic children.
3.   Game based language learning for dyslexic children.

The exclusion criteria are:
1.   Papers that do not consider interface design for dyslexic children environments.
2.   Not related to educational software design guidelines for dyslexic children language studies elements.
3.   Exclude the paper that was published before 2017.

2.4 Quality Assessment

To assess the quality of the papers selected in this study, each paper was evaluated by using the criteria from these quality assessment questions (QA):

QA1: Does the paper elaborate about the educational software for dyslexic children in details?
QA2: Does the methodology clearly stated?
QA3: Is the paper the paper elaborate results and discussion in details.?

The questions were scored as follows:

QA1: Y (yes), the study elaborated about the educational software design in detail.
 P (partly), the educational software design is not clearly elaborated in detail in the paper.
 N (no), the study did not elaborate about the educational software design in detail at all.

QA2: Y (yes), there are platform used to deliver educational software design
 P (partly), there are suggestions that the platform will be used to deliver educational software design.
 N (no), there is no platform mentioned in the study.

QA3: Y (yes), it has 4 or more papers with literature reviews that cover educational software design in the paper.

P (partly), there are 1 to 3 papers with literature reviews that cover related topics.
N (no), there are no literature reviews covered about educational software design in the paper at all.

The scoring procedure was Y = 1, P = 0.5, N = 0, or Unknown (i.e. the information is not specified)

3. Results and Discussion

Having browsed in the online databases, and searched using the strings in Section 2(b), a set of 25 research articles appropriate related works published in the last five years has been gathered. All papers are summarized in a table, in which the contents of the table (as seen in Table 2) include the following information: (a) Study title, (b) Author(s), (c) year of publication.

Table 2: Data Collection of Related Study

Paper No	Title	Author
1.	Digital games-based learning for children with dyslexia: A social constructivist perspective on engagement and learning during group game-play	(Vasalou et al., 2017)
2.	Interventions for children with dyslexia: A review on current intervention methods	(Yuzaidey et al., 2018)
3.	A Multisensory 3D Environment as Intervention to Aid Reading in Dyslexia: A Proposed Framework	(Broadhead et al., 2018)
4.	A Heuristic Evaluation of an Educational Game for Children with Dyslexia	(Ouherrou et al., 2018)
5.	Developing effective educative games for Arabic children primarily dyslexics	(El Kah & Lakhouaja, 2018)
6.	Arabic Alphabetic Puzzle Game Using Eye Tracking and Chatbot for Dyslexia	(Aljojo et al., 2018)
7.	V-learning: Virtual Reality Based Games For Dyslexia Improvement	(Aranha et al., 2019)
8.	Serious games in K-12 education: Benefits and impacts on students with attention, memory and developmental disabilities (dalam folder full text azli)	(Papanastasiou et al., 2017)

9.	Action video games improve reading abilities and visual-to-auditory attentional shifting in English-speaking children with dyslexia (dalam folder full text azli)	(Franceschini et al., 2017)
10.	Development of educational game for children with dyslexia. (dalam folder full text azli)	(Sholdova, 2020b)
11.	Design of Mobile Game-Based Learning Application for Children with Dyslexia (dalam folder full text azli)	(Bigueras, 2020)
12	Enhancing Attentional Control: Lessons from Action Video Games. (dalam folder full text azli)	(Bavelier & Green, 2019)
13	Action Video Games Enhance Attentional Control and Phonological Decoding in Children with Developmental Dyslexia. (dalam folder full text azli)	(Bertoni et al., 2021)
14	A framework for applying learning analytics in serious games for people with intellectual disabilities: Serious games analytics for intellectual disabilities (dalam folder full text azli)	(Nguyen et al., 2018)
15	Improving the readability of dyslexic learners with mobile game-based sight-word training (dalam folder full text Dr Sobri)	(Ansari et al., 2020)
16	Mobile Game-Based Learning to Enhance the Reading Performance of Dyslexic Children (dalam folder full text Dr Sobri)	(Bigueras, 2020)
17	Kinect-Based Learning Games for Dyslexic Children (dalam folder full text Dr Sobri)	(Sudarmilah, 2020)
18	Neither action nor phonological video games make dyslexic children read better (dalam folder full text Dr Sobri)	(Łuniewska et al., 2018)
19	Dyslexia and Fonts: Is a Specific Font Useful?	Bachmann 2018
20	Proposed user interface design criteria for children with dyslexia	Khen et al 2018
21	A Questionnaire-based Approach On Technology Acceptance Model For Mobile Digital Game-based Learning	Ghani et al 2019
22	Inter-letter spacing, inter-word spacing, and font with dyslexia-friendly features: testing text readability in people with and without dyslexia	(Galliussi et al., 2020)
23	Designing a New Puzzle App to Target Dyslexia Screening in Pre-Readers	(Rauschenberger et al., 2019)

| 24 | Designing Mobile Application for Dyslexia in Reading Disorder Problem | (Rahim et al., 2018) |
| 25 | Action Video Games Enhance Attentional Control and Phonological Decoding in Children with Developmental Dyslexia | (Bertoni et al., 2021) |

3.1 Quality Evaluation

The papers selected in this study were evaluated and scored by using the quality assessment questions mentioned above to identify the relevance of the article with the topic study. Each score was represented according to the criteria highlighted. Overall, the total scores were presented in a range of 1.5 to 4.0. The results are shown in table 4 below:

Table 5: Quality Evaluation of Various Articles Type.

	Topic & Authors	Article Type	QA1	QA2	QA3	Total Score
1	Vasalou et al., 2017	Manuscript	1	1	1	3
2	Yuzaidey et al., 2018	Journal	1	0.5	1	2.5
3	Broadhead et al., 2018	Conference Paper	1	0.5	1	2.5
4	Ouherrou et al., 2018	Conference Paper	1	1	1	3
5	El Kah & Lakhouaja, 2018	Journal	0.5	0.5	1	2
6	Aljojo et al., 2018	Journal	1	1	1	3
7	Shailan Aranha 2019	Project report	1	1	0.5	2.5
8	Papanastasiou et. al 2017	Journal	1	1	1	3
9	Franceschini 2017	Journal	1	1	1	3
10	Sholdova 2020	Journal	1	1	1	3
11	T. Bigueras 2020	Journal	1	0.5	0.5	2
12	Bigueras 2020	Journal	1	1	0.5	2.5
13	Bavelier & Green 2019	Journal	0.5	0.5	0.5	1.5
14	Bertoni et. al 2021	Reports	0.5	1	0.5	2
15	Nguyen et. al. 2018	Journal	1	0.5	0	2
1 6	Ansari et. al. 2020	Journal	1	1	0.5	2.5
17	Sudar Milah 2020	Journal	0.5	1	0.5	2

18	Łuniewska 2018	Journal	0.5	0.5	0.5	2.5
19	Bachmann 2018	Article	0.5	1	0.5	2
20	Khan et al 2018	Journal	1	1	1	3
21	Ghani et al 2019	Journal	0.5	1	0.5	2
22	Rauschenberg et al., 2019	Proceeding	1	1	1	3
23	Rahim et al	Conference	1	1	1	3
24	Galliusi et al 2020	Journal	0	1	1	2
25.	Bertoni et al 2021	Journal	0	1	1	2

4. Data Analysis

Table 2: Data Analysis of Related Study

Paper No	Paper	Criteria/ Guideline & theory used	Research Method
1.	Vasalou et al., 2017	Guidelines: Interaction, game design, engagement and learning employ a systematic Theory used: thematic analytic approach Game approach:	Sample: Primary school age: 11-12 Method: Developing, Testing
2.	Yuzaidey et al., 2018	Guideline:literacy and cognitive abilities Theory: the phonological intervention, and the cognitive training method Game platform:none	Sample: Studies on literature review
3.	Broadhead et al., 2018	Guideline:Promising approach Theory: Intervention aid reading Framework	Sample: teachers and student Method: Proposed framework, SLR

		Game platform: 3D environments and gaming technology	
4.	Ouherrou et al., 2018	Guideline: visible objects and coherent color to minimize children load memory, animation the most preferred elements for children in the game Theory:heuristic evaluation Game platform: Assistive technology	Sample: Eleven children with dyslexia aged between 8–12 years old Method: Development, Testing
5.	El Kah & Lakhouaja, 2018	Guidelines: Manifestation of dyslexia, The different shapes of Arabic letters, diacritical marks, the role of vowels or consonants Game platform: Word, sentences games	Sample: 46 pupils of the second grade from two primary schools in the east of Morocco (Al Shatiby primary school Method: Development & testing
6.	Aljojo et al., 2018	Guidelines: Focusing attention (Song letters, meaning, Sight words, grammar) Game platform: Puzzle game application based on eye tracking and a chatbot	Sample: 20 children Age: 4-7 years old Method: Review literature review, Interview, questionnaire, design & implementation Usability testing ● Pre-post questionnaire
7.	Shailan Aranha 2019	Guidelines: phonic and gross motor skills Theory: Learning based approach, multisensory approach Game platform: Virtual Reality	Sample; Beginner, professional Method: Data gathering, Building level, testing

8.	Papanastasiou et. al 2017	Guidelines: Engagement, creativity, control and communication. Theory: multi-sensory style of learning Game platform: video games	Method: Review paper
9.	Franceschini 2017	Guidelines: Theory:Reading skills and phonological working memory, visuo-spatial attention, auditory, visual and audio-visual stimuli localization, and cross-sensory attentional shifting Game platform: Action video games	Sample: 14 native Italian speaking children Method: Reading Tasks, Phonological Decoding Tasks, Word Reading Tasks,Visual Search Task
10.	Shaldova 2020	Guidelines:The choice of background and text colors plays a big role in reading ability: Pastel colors, text: less brightness Theory:multi-sensory learning style Game platform: Mobile application	Sample: from elementary school,upper grade Method: Development, analysis
11	Bigueras 2020	Guidelines: game design elements, content design, screen layout, game environment, learner needs, learning objectives and the pedagogical approach. Theory: game based approach Game Platform: Game-Based Learning System	Sample: Children Method: The descriptive and developmental method

12	Bavelier & Green 2019	Guidelines: game genres, game mechanics, game taxonomy Game platform: Video games	Sample:- Method: The descriptive and developmental
13	Nguyen et. al. 2018	Guideline:learner profiling, learning adaptation and learning evaluation. Theory: framework outlines Game platform: Serous game	Sample:Studies on literature review Method: design, implementation, evaluation and adaptation
14	(Ntoa et al., 2015)	Guidelines: Learning the home environment, Learning about money and monetary transactions, Learning how to cook simple meals Theory: Cognitive impairments Game platform: Multimodal Interactive system	Sample: Pres-school (4-5 years) Method: questionnaire and interviews
15	Ansari et. al. 2020	Intervention techniques: speed of processing letter and syllable pattern Theory: Mobile game-based approach Game platform: Sight-word based Mobile game	Sample: of eight female special educators aged between 23 to 40, Method: a follow-up intervention technique
16	T. Bigueras 2020	Guideline: Game element of Story. point and rewards,Clear Game Goals and Objectives.Level. feedback, achievement system Theory: -	Sample: 12 students Method: Implementation, pre and post test

		Game platform: mobile game-based	
17	Sudarmilah 2020	Guideline: Game element, music and sound, display, testing educational game, letter types Theory: System Development Life Cycle Game platform: Mobile game application	Sample: Expert Method: SDLC (System Development Life Cycle) method of the Waterfall model
18	Łuniewska 2018	Guidelines: Reading tasks.Phonological tasks, Attentional tasks, Web-based reading tasks Game platform: video games	Sample: Fify-four dyslexic children (36 boys, 18 girls) Method: AVG vs. PN AVG comparison. Training groups.
19	Bachmann 2018	Guideline: Font: a specific font called EasyReading, big size, a simple design, and a special serif. Game platform: -	Sample: Sixteen primary schools Method: Reading testing
20	Khan et al 2018	Guideline: User interface design criteria: font, text, color contrast, input methods Game platform: Mobile application	Sample: 6 children with dyslexia Method: design and implementation
21	Ghani et al 2019	Guidelines: four variables being studied, perceived usefulness, perceived ease of use, attitude and behavioural intention to use Theory/approach/model: TAM models Game platform: Mobile game based	Sample:40 Universiti Malaysia Kelantan (UMK) undergraduate students Method: quantitative approach

22	Bertoni et al., 2021	Guidelines: attentional control, attentional control and phonological decoding speed	Sample:14 native Italian speaking children
		Theory: -	Method: Interview, test AVG and Non AVG
		Game platform: Action Video Games	
23	Galliussi et al., 2020	Guidelines: class of fonts, Reading accuracy and speed	Sample: 64 children each
		Theory:	Method: Experiment
		Game Platform:-	
24	Rauschenberger et al., 2019	Guidelines: telemetry of the gaming sequence,	Sample: five German-speaking child parent pairs
		Theory: the human-centred design	Method: Design, Procedure, Participants
		Game Platform: Puzzle Game	
25	Rahim et al., 2018	Guidelines: characteristics of the people with Dyslexia specifically children, learning style of Dyslexia children	Sample:Principal and teachers
			Method: Field work, interview, SLR
		Theory:multi-sensory method	
		Game Platform:Mobile Application	

RQ1: What are the methodology used in research related to educational software for dylexic Children?

Multiple methods have been used in research related to educational software for dylexic Children. It will be seen that the research methods are divided into 4 categories. They are as follows: Quantitative method, qualitative method, conceptual method. and mixed methodologies as shown in Fig. 1.0. Out of the complete 25 primary studies, 10 used qualitative

methodology, and 3 used quantitative methodology. In addition,2 were conceptual and 6 used mixed methodologies.
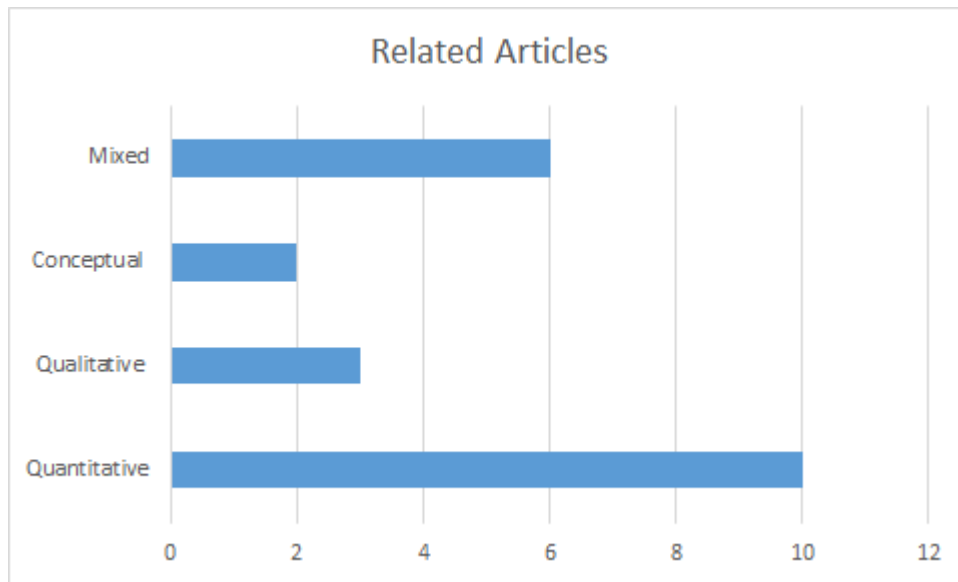

Figure 1.0

What are the characteristics of the participants in the studies

Sample demographics used in every past paper have been divided by four categories which are children, adult, literature review and children with adults as shown in Figure 2.0. Out of a total of 25 studies, 12 were evaluated using children, 4 were made using adults, and 5 studies using both children and adults in their sample (Fig. 2.0). The largest number of participants had studies which used xs van children as a method of evaluation.
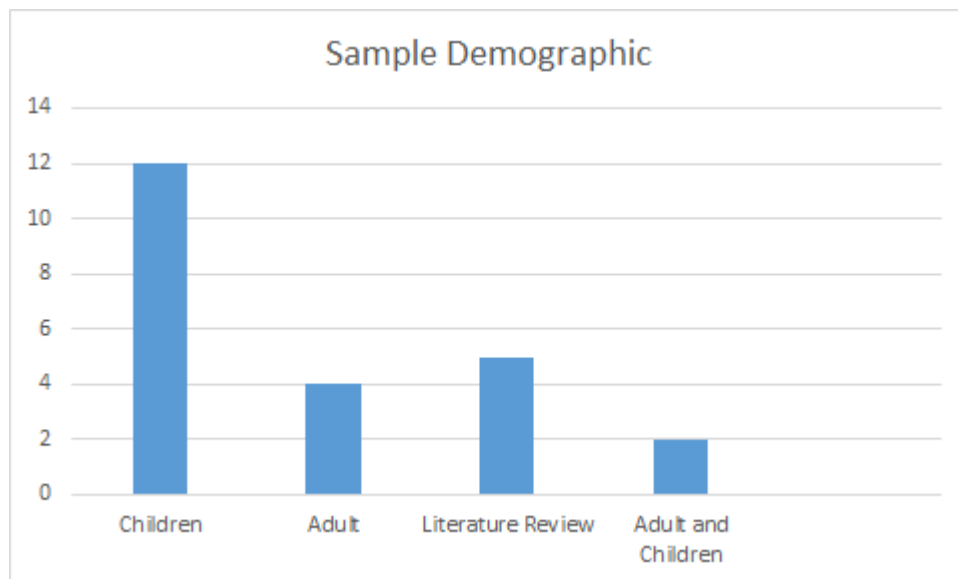
Figure 2.0

4.1 Fonts

Specific Learning Difficulty (SLD) such as dyslexia needs help from the others especially teachers and their parents to assist them. However, features in game can be a tool to help them in the learning process. Dyslexic learners need a special font for every game that is built for them. Dyslexic students also often find themselves facing some tasks in paper format, in which they are obliged to read (Bachmann & Mengheri, 2018). Several publishers of books are specializing in suitable fonts for dyslexics and are publishing books specially designed for different age ranges of the audience (Bachmann & Mengheri, 2018). Moreover, some groups of people with dyslexia read faster when a text is rendered with increased inter-letter and inter-word spacing (Galliussi et al., 2020). Dyslexia friendly (DF). DF fonts are thought to help people with dyslexia to recognize letters, distinguish between letters of similar shapes, and limit crowding effects. Indeed, the facilitating characteristics are a specific letterform (i.e., increased thickness near the bottom; angling and changing the height and the contours of similarly shaped letters; serif or sans serif types) to prevent reversals, rotations, and misordering, and an increased spacing to limit crowding (Galliussi et al., 2020)

4.2 Visual

A number of studies found that individuals with dyslexia show an asymmetrical distribution of their visual attention, with better performance on targets in the right than the left visual field, while controls performed equally well on both sides (Khan et al., 2018)

4.3 Sound

Narration with written text was found to be especially beneficial for students who have weak reading or language skills (Dunsworth & Atkinson, 2007). Indeed, better readers have less preference for adding audio to written text than poor readers which has to do with the pacing of the audio (Gerbier et al., 2018). Gerbier, Billy and Bosse (2018) argued that this pacing has to be aligned with students' reading speed to optimize learning.A mobile application with a sound aid is a powerful tool in helping people with dyslexia to cope with their disabilities.

4.4 Colour

Poor coloured text is one of the main problems encountered by people with dyslexia. According to the dyslexia association of Ireland and British Dyslexia Association (Khan et al., 2018), it is better to use a coloured background than white because white can appear dazzling to some children with dyslexia. According to the association, colours like cream, off white and pastel colour can ease reading. However, some Dyslexics may have their own preference of colour such as yellow or blue (Khan et al., 2018)

4.5 Text

The study found that a text written in Comic Sans MS font family over a yellow background is the most suitable combination for dyslexics (Khan et al., 2018).

RQ3 What was the platform used to deliver learning for dylexic children?

Platforms used in every past paper have been divided by four categories which are games, mobile application, courseware and none of three as shown in Figure 3.0. Out of a total of 25 studies, 9 were evaluated using games, 8 were using mobile application, and 7 studies using courseware in their research (Fig. 3.0). The largest number of platform that had been used in this review paper was using games.
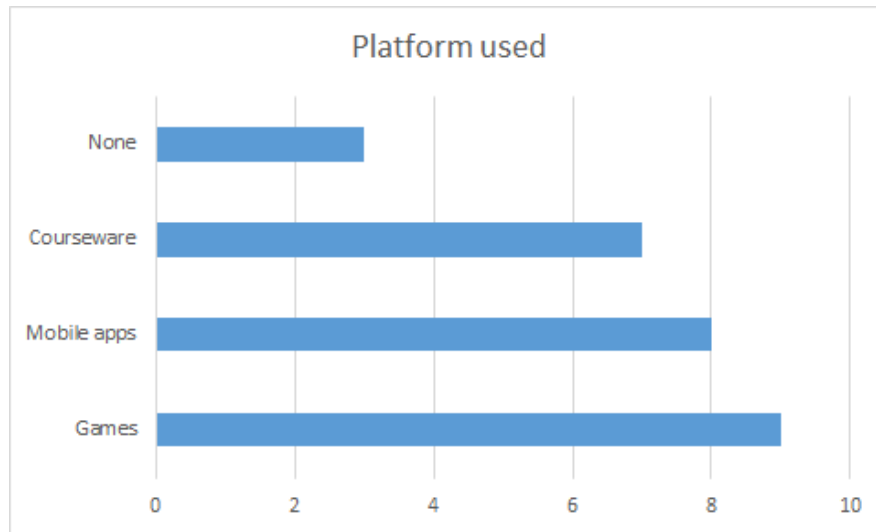

Figure 3.0

5. Conclusion

This paper reviewed 25 studies in the field of educational software for children with Dyslexia. While selecting the studies for analysis, the focus was on all solutions that include educational software and are designed for children whose primary disability is Dyslexia. The results of the systematic literature review showed that the most common methodology used was quantitative method. Most of the research involved children as their participants.

In this research, the researcher found that children with dyslexic are facing the problem of identifying characters in Arabic that share similar words or similar sounds. In addition, background color and words are affecting the reading of children with dyslexic. User interface with some improvement defines the way how they will use the software. Therefore, educational software play an important roles to help children with dyslexia to read better in Arabic.

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