International Journal of Advanced Trends in Computer Science and Engineering

User Interface Guidelines for Dyslexic Game-Based Learning on Selected Usability Test Method

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ABSTRACT

Multimedia technology is constantly growing and benefitted every facet of our lives and has its impact felt to modern education. Despite many products that utilize multimedia technology for education such as e-Learning and learning courseware, there is a lack of development in the designs of educational products for students with Dyslexia. User Centred Design guidelines on developing software for Dyslexic user is still under investigation and most published guidelines are focusing more on web accessibility and not specific for game-based learning. This paper presents a set of practical interface design guidelines to improve learning process of a game-based learning for the dyslexic students. The guidelines are developed based on survey conducted and proposed elements in Human Computer Interaction (HCI) that is essential in improving learning process. Within the paper, we showed that using of the proposed guidelines can improved the learning process for Dyslexia students.

Key words: E-learning, Dyslexia, Human Computer Interaction, Game-based Learning, Usability

1. INTRODUCTION

Game-Based Learning (GBL) is a type of game play that can assist achieving positive learning outcomes. Essentially, game play elements are integrated in the learning process in order to deliver intended content. Content such as storylines, timer, points, missions and puzzle can be conveyed using gameplays through the use of GBL. GBL is seen as an alternative method to learning apart from conventional and traditional methods of chalk-and-talk still found in classroom today. It is one of the more modern learning styles that many educators are currently adopting in their teaching and learning including at the university level. One of the famous GBL tools nowadays is Kahoot which allow educators to prepare game-type quizzes in a form of multiple-choice questions and the system would be to track answers of each students and finally transforms marks into data for analysis.

The conventional learning strategies however that not suit well with students with dyslexia. Dyslexia is a form of disability present in growing number of students in the world which condition them to a certain level of difficulty in reading and writing. The difficulty affects the basic variables of reading performance – speed, correctness, reading technique and comprehension [1]. Hence, students with dyslexia often have problems in writing, spelling, speaking and mathematics. Proper teaching techniques and tools that suit students with dyslexia need to be identified in order to motivate and encourage them to engage and be part of teaching and learning in schools. This is where computer and multimedia technologies could come in and assist in their learning.

Most researchers in previous and current studies try to explore and find ways to help dyslexic students to realize their potential despite having difficulties in coping with learning problems in acquiring knowledge [2]. GBL is one of the learning strategies that could assist dyslexic students experience education in new and interactive ways while increasing their interest and focus towards acquiring knowledge.

2. RELATED WORK

According to Geurts et. in their research, a normal computer-based learning with interactive user interface and added animations is still difficult to keep the child's attention at a high level throughout the learning [3]. Therefore, by incorporating fun and challenging application such as a game-based learning would increase dyslexic students' motivation to continue learning. Brown [4] states that dyslexic students are able to comprehend meaning from what is being spoken about a picture. Based on Edgar Dale's Audio-Visual Methods in Teaching, interactive media dan media production can help students remember 70% to 90% of what students has said and done and game-based learning are placed between this level.

There is still lack of research that focuses on applying HCI on game-based learning specifically to children with dyslexia learning disability. Most efforts focused on how to support

users that are blind or have low vision. Others work with Dyslexia is lack of usability analysis [5]-[7]. In [8] created educational multimedia App which used the Principle of Multimedia Design [9] – [10] and the Usability Framework for mobile Learning [11] as guidelines to design user interface and navigation in developing the application. However, the work relied only on expert view where user experience is not included.

2.1 Design Principle

Design Principles are standards used to organize and arrange the structural components of Software Engineering design. The applied principles affect the expressive content and the working process from the start. The principles can guide the designer during the design process and used to evaluate and critique prototype design ideas.

Table 1 below list all twelve principles for good human-centred design which systems should be learnable, effective and accommodating [12].

Table 1: Design Principles and the purpose

Principles	Purpose
1. Visibility 2. Consistency 3. Familiarity 4. Affordance	Helping people access, learn and remember the system.
5. Navigation 6. Control 7. Feedback	Giving them the sense of being in control, knowing what to do and how to do it.
8. Recovery 9. Constraints	Safely and securely.
10. Flexibility 11. Style 12. Conviviality	In a way, that suits them.

2.2 Usability Test Method

The usability of the system depends on the user to design the usable interface. Benyon in his book [12] stated that to achieve the usability, the four principal factors of human-centred interactive system design must be balanced. The four principal is People (user), Activities (task), Context (environment), and Technology (tool) also called as PACT.

Usability test is a process of systematically collecting the usability data of interface and usage of the application in which then will be assessed for further improvements. A good design of user interface would enhance the human interaction with the system making it more effective, easier with lesser possibilities of human errors.

Nielsen model has been used as a reference quality model for this study because it is an international standard for the evaluation of the mobile and web application. International Standards Organization in the ISO 9241-11 Guidance of

Usability defined usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Nielsen associates five attributes to usability:

- **Learnability** – Do users easily master the basic functions during the first encounter with interface design of software product?
- **Efficiency** – How fast can users do the tasks when they get familiar with the interface design?
- **Memorability** – How easily users get comfortable with the system functions especially when they are not using it after certain period of time?
- **Errors** – How easily users make errors, how serious the errors made and how easily can they amends the errors?
- **Satisfaction** – How enjoyable and comfortable is it to work with the system?

There are many types of usability testing to evaluate how user experience with the end product. Usability testing can be both expensive and time consuming. Therefore, selecting adequate and suitable usability test can potentially acquires favourable users' participations, quick turn-around on getting the requirement, and significant cost savings [13].

In [14] shows the comparison of evaluated usability testing methods that been used in current software engineering practices and the attributes that has been compared are high velocity, low cost, flexibility, resource requirement, how many to test, test type, impact of evaluators experience on test result, level of found problems and method purpose. Thus, this study will use Focus Group Method as its usability test due to its suitability with users being children with Dyslexia.

3. METHODOLOGY

The study was carried out with a qualitative research approach, which is suitable for usability analysis and also supported with questionnaires to increase accuracy of the analysis. There were six randomly children with dyslexia disability participated in the study. They were chosen without any special criteria except all are computer user. The following table shows the summary details of respondents. We also did unstructured interviews with their teachers to assist us of their students' understanding towards learning.

Table 2: Respondents

Respondent(R)	R1	R2	R3	R4	R5	R6
Age (Year)	8	9	9	10	10	11
Gender	Girl	Girl	Boy	Boy	Boy	Boy
Dyslexic Categorization	Mild	Mild	Mild	Mild	Moderate	Severe

The study was conducted in two sessions. The purpose of the first session was used as a pilot study. The later session is to evaluate the proposed guidelines.

First, the dyslexic children were given to try alphabet games that are available online. The games are Alphabet Order and Alphabet Antics which are not design for children with learning disability. These games objectives are to help children to recognize the letters and its order.

Alphabet Order as shown in Figure 1 is a game whereby the user need to arrange the letters in a correct sequence by using Drag and Drop activity. User need to drag and drop each letter in a correct order. There was also a sound that pronounce each selected letter. This game is very straight forward and there is simple instruction that ask the user to help the monkey to put the alphabet into the right order.

Alphabet Antics is a game to help student to recognize the letter from the pronounced letter. There are two sections in this game and the first section is where the user can click on the letter to hear the pronounce of the letter. The second section is where the game is taking place. The mission of this game is to select the correct letter that were pronounced by the monkey. Each correct answer will make the monkey climb higher and each wrong answer will make the monkey go lower to the ground and can be bitten by a snake when the monkey failed to select the correct letter. Figure 2 shows interface of the game.

Following that activity, the children were asked to complete the satisfactory survey with the help from teacher. Each question from the survey were read aloud twice to make them understand and think wisely. The survey was composed into two sections; Usability Evaluation and Suggestion.

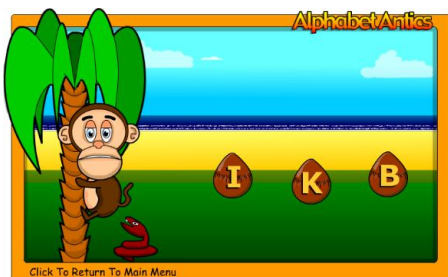**Figure 1:** Interfaces Design of Alphabet Order

Figure 2: Interfaces Design of Alphabet Antics

1. Usability Evaluation Section

By referring to Nielsen model, the attributes of usability tested are learnability, efficiency, memorability, errors, and satisfaction

Evaluation process would involve the use of Likert-scale and Questionnaire for User Interaction Satisfaction (QUIS). Distribution of questions for each attribute are:

- 3 questions for Learnability
- 4 questions for Efficiency,
- 2 questions for Memorability,
- 2 questions for Errors,
- 2 questions for Satisfaction.

Five-point Likert-type scale was used to evaluate the usability of the game sample, with the items "Strongly Disagree", "Disagree", "Undecided", "Agree", "Strongly Agree" was used and the responses will be evaluated according to the merit point as Table 3 below.

Table 3: Likert-scale Option and Merit

Option	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Merit	1	2	3	4	5

2. Suggestion Section

This section is based on Open-ended Question whereby the teacher's opinions and views were asked to get a better understanding of the learning environment for children with dyslexia and what are the best type of learning approach in term of instructional design that can be used to improve the engagement of their learning.

After the study, the questionnaire and interview results together with notes from related literature including HCI design were analyzed in parallel to propose a design guidelines. An evaluation on the proposed guideline would be carried out by developing a simple game for student with dyslexia to attempt. The same questionnaire would be used to the same respondent to get the feedback whether the proposed guideline help in improving usability of game-based learning application for dyslexic children.

4 THE PROPOSED GUIDELINES

Table 4 shows the proposed guideline for the game design and divided into six categories started from Usage of Font, Color, Navigation, Consistency, Interaction and Game Type.

In order to increase readability, there would a special attention given to the use of font, size of font, type of font, small or capital letter, and also the spacing between each letter. This guideline on usage of font was also supported by previous studies from [5], [15] and [16]. Special focus would also be given to the use of colours in the background and text for the whole user interface of the game. Navigation within the application would also covers on how easy the users to go from main page to another page in order to complete the game. Consistency category is about using the same concept either for navigation, icon, design, font and layout starting from the Main Page until the end of game. The Interaction category would focuses on how the games interact with the user in term of giving instruction and respond on each

activity. It also covers the feedback or effect as a respond to each action from user. Game type category defines how the activity will be or what types of game were preferred by the user. For this study, it is suitable to design the game that only require minimal click and there is why Drag and Drop features are suggested in this game.

Table 4: Guideline for Game Design

Usage of Font	• Use large font size: **18 to 26 points** • Suggested font **Helvetica**, **Arial** or **Verdana**.(Rello, 2013) • Use **small letter** (Ismail & Jaafar, 2014) • Character spacing +7% (Rello, Kanvinde, & Baeza-Yates, 2012)
Color	• Use dark color text on a light background. • Suggested use cream color background.
Navigation	• Simple navigation. From Home / Main Menu direct to another page
Consistency	• Use same theme/design for entire game design such as buttons, instructions, and layout.
Interaction	• Simple and straight forward instruction in text and voice over. • Avoid using too much flashing and moving text.
Game type	• Simple click (not too many items to click) • Drag and drop

5 PROTOTYPE IMPLEMENTATION

The prototype is developed based on the proposed guidelines. The purpose of developing prototype in this study is to improve the usability level for each attribute that were collected during the pilot study of the usability test. This prototype was developed using Articulate Storyline and it is a web-based application which runs using a web browser

Figure 3 shows the main page of the prototype called pLexic. The game is using metaphor of children school as design concept for the user interface design. This design is to get the attention of the children and related to learning. There are only two buttons on the main page because the instructional design is to simplify the navigation of the entire game so that the Dyslexic children can easily navigate through both section alphabet and section play game. Both buttons were using small letter because capital letters take a longer time for those with learning difficulties like dyslexia to interpret the letter into meaningful words [15]. The background color is also using the suggested color which is cream color as Dyslexic children prefer to use dark color text on a light background.

A. Alphabet Section

This section is to simply teach the sound of each letter in small letter and the example of the word for each letter. To make the application more learnable and interactive for

dyslexic children, there are avatar of teacher with voice over as an instruction to guide the dyslexic student on what to do for this section. The used of the avatar of the teacher is to add a human element in the game environment so that it will represent learning and teaching in the classroom. The instruction is very straight forward and simple so that it will not confusing the children. There is also mouse over features that will sound each letter when the cursor pointing on the letters. There was also a home icon as a button to navigate to Main Menu. The home icon is commonly used in lots of software and application and it was familiar with the Dyslexic children.

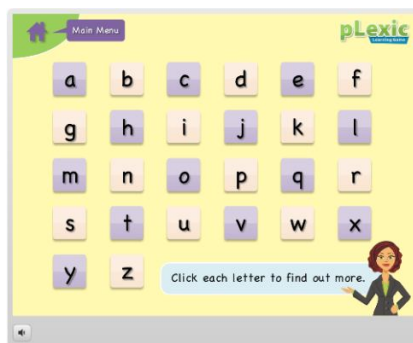**Figure 3:** Main Page of pLexic Learning Game

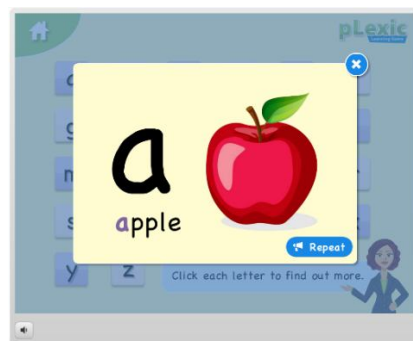**Figure 4:** Alphabet Section Interface

Figure 5: Alphabet Section Activities Example

When each button is clicked, there will be a popup window of the letter with example of word and picture. The example words and pictures are the most common among the children and this will help Dyslexic user to recognize the spelling and the sound of the word as shown in Figure 4 and Figure 5.

B. *Play Game Section*

There are two types of activities in this section, Drag & Drop and Multiple Choice using Augmented Reality. The game is based on the content from Alphabet section. This will test the understanding and memorability of user when go through the Alphabet section.

For the Drag & Drop activity, the children need to drag the correct letter into the box and then click the Submit button as shown in Figure 6. The letter that were used is the most common mistakes letter by children with dyslexia learning disabilities. This activity will help Dyslexic children to memorize and identify the correct letter for each word. Dyslexic children can click the speaker icon so that the voice over can pronounce the word again.

The Augmented Reality feature is to apply blended learning to attract Dyslexic student top focus on the learning. Augmented reality is a user interface technology in which a camera-recorded view of the real world is augmented with computer-generated content such as annotations, graphics, animations, and three-dimensional (3-D) models. Augmented Reality in this game aims to motivate children to be more physically active and learn by using nowadays-basic smartphone.
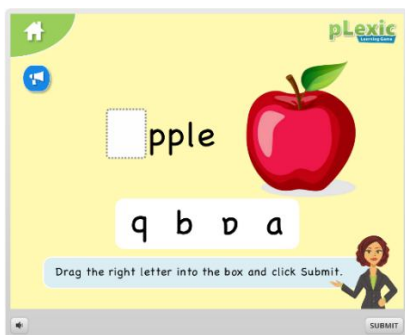

Figure 6: Drag and Drop Activity

Figure 7: Multiple Choice activity using Augmented Reality

In this activity, user needed to use smartphone that already been installed the learning application to enable the Augmented Reality feature for this learning activity. By using the smartphone, user could scan the screen and the next instruction would appear on the smartphone. The users would then need to choose the correct letter that was placed in the box. The purpose of this activity was to help attract the

children to focus on the learning proses using the fun element from Augmented Reality features and this were also suggested by the teacher at the Dyslexic center.

6. RESULT AND FINDINGS

Five usability attributes were evaluated and analyzed by asking the children to answer the questionnaire in order to assess the usability level of games with some helps from their teachers. 17 number of question items were distributed into the main five attributes; learnability, efficiency, memorability, errors, and satisfaction according to Nielsen's usability model.

Before applying the guidelines, the memorability attributes had the lowest point of in usability test which is 2.42. This would indicate that the level of the game's usability was poor and did not help Dyslexic children to access the games properly. The satisfaction attribute showed only 2.47 which implied that the Dyslexic children did not enjoy learning through the games. Both memorability and satisfaction attribute scored less than half and the highest score recorded was 3.25 for errors attribute which showed that the games were not pleasant for the Dyslexic children. The result for overall usability for the test is 2.80 which was considered at moderate level of usability.

There were a few suggestions and recommendations from the Dyslexic students and the two assisting teachers. The suggestions were categorized in Interaction, Colour, Font and Consistency as shown in Table 5.

Table 5: Suggestions and Recommendations

Interaction	• Use simple and short instructions • Don't use so many buttons in different shape/design • Need to apply new approach to attract attention. (Recommend using phone as a blended learning with the computer)
Color	• Use dark color text on a light background
Font	• Use big font size • A spacing between each letter need to be in same length.
Consistency	• Use same theme/design for entire game design such as buttons, instructions, and layout.

Thus, while applying the guidelines in the prototype, the result showed improvements on every attribute. The following figure showed the comparison of the usability point for Usability Test before and after applying guidelines. These findings implied that the guidelines could be used to increase the satisfaction on Dyslexic children on using the game-based learning. The result for overall of this usability test was 3.64 which was considered at Good level of usability
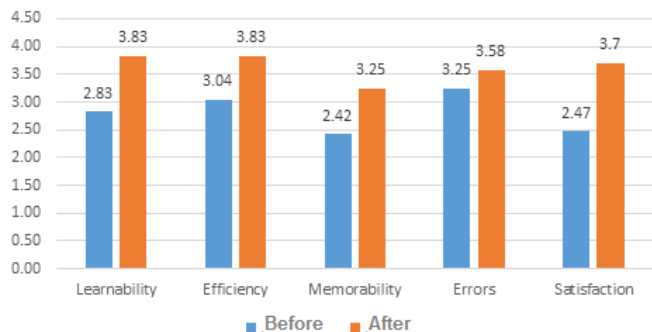
Figure 8: Before and After applying Guidelines

The following table shows the summary result of usability points for each attributes.

Table 6: Usability Points and Level for Prototype Usability Test

Factors	Usability Points, x	Usability Level
Learnability	3.83	Good
Efficiency	3.83	Good
Memorability	3.25	Moderate
Errors	3.58	Good
Satisfaction	3.70	Good

We believed the improvement was due to the prototype was developed based on the guidelines that were made to cater Dyslexic children accessibility throughout the basic HCI design. The guidelines specified six categories of design such as usage of font, colour, navigation, consistency, interaction and game type. All of these categories were in accordance to the feedback from the Dyslexic children.

The result from evaluating the usability of the samples game-based learning and the prototype were analysed to see whether the proposed guidelines could improvise the usability aspect of the game. Both result from pilot study and prototype were compared and it showed that there was an improvement on usability attributes like learnability, efficiency, memorability, errors and satisfaction of the user interface design. The proposed guidelines showed that it can assist Dyslexic student to improve the accessibility of the game-based learning.

6. CONCLUSION

This research contributes to learning for community with disability by doing a study on improving user accessibility on multimedia product that is designed specifically for dyslexic children. This study also contributes to software engineering field in term of Human Computer Interaction by providing a development guideline on designing a suitable user interface that can improve accessibility for children with disability to learn using any multimedia product.

As for the future work on this field of study, there is a need for studies that could focus on the type of games that can support dyslexic students through the use of HCI that can be applied in software engineering. This future study would identify the best type of games that can improve learning process of students with Dyslexia.

ACKNOWLEDGEMENT

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