Mathematics courseware for dyscalculia students (MCDYs)

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ABSTRACT

MCDys is a courseware created as a learning tool for students with dyscalculia. The syllabus is developed based on the Linus module that is provided by the Kementerian Pendidikan Malaysia (KPM). Dyscalculia is a term used for learners that have a disability in learning mathematics. In developing this courseware, ADDIE model is used. ADDIE is a framework that many instructional designers and developers use to develop the courses. There are five stages in ADDIE Model which are analysis, design, development, implementation, and evaluation. To design the interface, Schneiderman's eight golden rules of interface design is used. Schneiderman's eight golden rules include striving for consistency, enabling frequent users to use shortcuts, offering informative feedback, designing dialogue to yield closure, offering simple error handling, permitting easy reversal of actions, supporting internal locus of control and reducing short-term memory load. The content of the courseware uses interactive approaches such as video, animation, and quizzes, and game-based activities to encourage users' understanding and grab their attention. User evaluation and expert evaluation were conducted to test the effectiveness and acceptance of the interface, usability, activity, navigation, multimedia, sound, image, text, animation, and video. The results show that the courseware has the highest score for usability score with a mean of 4.6(SD=0.55). For future enhancement, more animation will be explored to suit the dyscalculia students' learning.

Keywords: courseware, Dyscalculia, ADDIE Model, Mathematics, Schneiderman's

1.0 INTRODUCTION

Courseware is a mixture of 'course' and 'software' phrases. This courseware includes several categories, including educational material, training, and instructional strategies. Courseware is an educational software used for digital education that utilize technology in learning. It comprises extra instructional content designed as teachers' kit or students' learning materials which is generally used with a laptop. The term dyscalculia is a mixture of the prefix 'dys' originated in Greek which means 'poorly' and the word 'calcula' that comes from 'calculare', a Latin word, which means 'to count'. Therefore, the meaning of dyscalculia is 'counting badly' (Kadosh *et al*, 2006). Dyscalculia students only learn for a few hours and the teacher teaches using their own creativity. The students also have some difficulties to learn such as slow in writing. In order to solve this problem, Kementerian Pendidikan Malaysia (KPM) has provided a Linus module for the dyscalculia students. Figure 1 shows the cover page of Linus module provided by the KPM.

Figure 1: Kementerian Pendidikan Malaysia Linus Module

In this module, KPM provided a plan for their learning. Ten topics will be covered within 29 weeks. For the first phase, students will learn Topic 1 which contains a whole number from 1 to 10 and take about seven weeks to complete it. In this topic, students will learn to pronounce and identify numbers. Through these activities, students will be able to express quantities intuitively where they can compare two numbers and state which one is which. For the final phase, students will learn on how to identify two-dimensional form. At the end of the lesson, students will be able to identify and name the two-dimensional form, list its characteristics, classify and create a two-dimensional design.

In learning Mathematics, students need practices and exercises to help enhance their understanding. However, the students will quickly get bored when the time taken by the teacher is too long. Not only that, dyscalculia students usually need more time to comprehend the concepts taught by the teacher. When teachers are teaching too fast, they may lose focus while learning. Therefore, teachers need to find other ways to teach dyscalculia students.

According to Miundy et. al. (2019), learners that suffer from dyscalculia have trouble in understanding even basic mathematical concepts and are often left behind in acquiring other fundamental areas of Mathematics. Other than that, the dyscalculia students are less confident to arrange numbers, pronounce the numbers and counting numbers. For example, they cannot arrange the number 1 to 20 and the behavioural characteristics that can be seen in some of the problematic learners are having difficulty in focusing, being distracted, overly active and restless, and not following the instructions and so on. These behavioural problems will

interfere with the class and may cause unpleasantness to teachers and other students. To solve this problem, creating an animation will attract the students towards learning and help decrease their hyperactivity.

2.0 LITERATURE REVIEW

2.1 Elements of Multimedia

Multimedia elements like sound, text, animations, images, and videos can help analyse the product information or content and save time to remember and understand the information. Text in multimedia applications may inspect or reinforce specific information contained in other media products. Text and words play an important role in the multimedia presentation and can help the users to communicate and understand the idea and message. Text-based information is simple and inexpensive to develop and needs minimal computer memory (Khedif et al, 2014). Audio is the main multimedia component. The audio word is used in analogue and digitized form of the sound. According to Khedif et.al (2014), sound has obvious advantages in offering older kids with undeveloped reading experience useful content. Text and images without any sound are useful when presenting in front of the viewers. Computer stores photos as pixel maps or as bitmaps. A small spot on the screen is a per-pixel (short for images). The guide is a double stitch point. The bitmap is, therefore, the simplest matrix of the dots on the computer screen that comprises the small images. The color values of each pixel are represented. At the time where an image is sent to be displayed, images are converted into pixels (Mukherjee, 2018). Animation can contribute great power to any implementation of multimedia. There are two types of animation which are 2-dimensional (2D) or 3-dimensional (3D). In 2D animation, the x and y-axis of the screen are visually modified. The graphic shift takes place in 3D animation along three axes: x, y, and z. This sort of animation provides almost a realistic perspective of the picture that people can see in their eyes.

2.2 Dyscalculia

The research tried to get to the root of dyscalculia through an examination of multiple skills not linked to the handling of numbers which are supposed to underlie dyscalculia (Landerl et al, 2004). Dealing with dyscalculia students gives the picture of general learning ability issues among children in Mathematics. It does not only affect school but can also have an impact on their daily lives. The early stage to know whether the student has dyscalculia is by observing their responses in class when the teachers give exercise and the students' age range is from 6 years old and above. There are several syndromes of dyscalculia which result in inconsistent calculations like subtraction, multiplication, and division. These conditions are commonly seen when students are writing, reading, and recalling numbers.

Behavioral Characteristics are one type of characteristics shown by students with dyscalculia. Traditionally, the defining characteristics of dyscalculia are poor arithmetical memory recovery and the persistence of untimely calculation strategies (Price and Ansari, 2013). However, a growing body of evidence for behavioral and neuroimaging in the last decade suggests that dyscalculia may arise in impairs of a neurobiological system for the processing of numerical dimensions, the total number of elements in one set and that this impairment leads to difficulties in the retrieval of arithmetic faculties through learning and development. Next is the Arithmetic. The cognitive feature of dyscalculia that has been seen most frequently is arithmetically impaired reality recovery (Mazzocco et al, 2013).

2.3 Schneiderman's Eight Golden Rules of Interface Design

The Schneiderman's eight golden rules include striving for consistency, enabling frequent users to use shortcuts, offering informative feedback, designing dialogue to yield closure, offering simple error handling, permitting easy reversal of actions, supporting internal locus of control and reducing short-term memory load. The first principle is consistency striving. The significance of this principle is to attain or strive for the coherence of an item based on harsh explications. Incomparable circumstances and consistent action sequences should be needed (Cronholm, 2009) as applied in the Schneiderman's eight golden rules.

Consistent interfaces allow the user to be aware of the system so that the system can be used correctly (Peri Cha & Romli, 2016). Next, the other rule allows the customer to use the shortcut. The use of shortcuts can save time and enhance the efficiency of professionals. Many shortcuts are available, like macros, unique key sequences, and abbreviations, which are used widely for periodic actions (Mazumder, 2015). This is an added value to the application but is not necessary since users cannot be aware of the function of a fresh implementation at an original level. This decreases time and avoids significant schemes and customer errors (Peri Cha & Romli, 2016).

The third rule is to provide information. Feedback should be provided for each operator's action (Cronholm, 2009). The informative feedback will be a message box directing them to what they should do when the customer does not enter the correct format. This is also the case when users click the menu, information feedback is shown as they know the current status and the user will be informed about what to do on this interface condition (Peri Cha & Romli, 2016). The fourth principle relates to the design of yield dialogs. A series of tasks must be grouped so that the user can perform all the tasks needed. Informational feedback when the group of activities is finalized gives the participants satisfaction in their achievement, a sense of relief, a signal to drop contingency plans and options as well as indicates that there are clear ways to prepare for the following group of actions (Cronholm, 2009).

The fifth rule is to offer error prevention and handle simple error. This law aims to avoid the mistake and to make it easy to handle or retrieve errors when a mistake occurs. This avoids error and offers a command to retrieve an error (Mazumder,2015). Failure to avoid and manage errors can discourage a customer from erring and if done, clear and informative directions are provided to recover (Peri Cha & Romli, 2016). The sixth rule is the permit easy reversal of action. This principle gives the user the ability to reverse any intervention that they have taken so that the customer can recover fast from a mistake. This feature helps to ease fear as the user knows it can remove errors so that unfamiliar options can be explored (Peri Cha & Romli, 2016).

Table 1: Comparison Similar Existing Courseware

Features	Multimedia Elements	Provided Guidance	Response	User Friendly	Learning Voice
MathLexic	✘ (no video)	✓	✓	✓	✘
MyLexic	✓	✘	✘	✓	✓
MEL-SinD	✘ (no video)	✘	✘	✓	✘
Proposed Courseware	✓	✓	✓	✓	✓

The seventh rule is to support internal locus of control. This rule ensures that the user is the person responsible for the system and not the system controller. Experienced providers highly want to know that they are responsible for the scheme and that the scheme reacts to its activities (Cronholm, 2009). This is essential because the customer can do whatever he wants without system command. The user can leave and come back and the system is still in the same condition (Peri Cha & Romli, 2016). The eighth rule is to reduce short-term memory load. Limiting human data in short-term memory needs easy screens, strengthening of multi-page screens, reduction of the frequency of window motion and appropriate learning time for codes, mnemonics and action sequences (Cronholm, 2009). In memory terminology, an ordinary person can remember only a short time approximately seven items. The displaying of an interface should be

easy, reduce a short-term memory load and design the interfaces as simple as possible (Peri Cha & Romli, 2016). MathLexic, MyLexics, and MEL-SinD are the existing mathematics courseware for the students with dyscalculia. Table 1 shows the summary of comparison similar existing coursewares. The summary includes features, five multimedia elements, provided guidance, effector message, user friendliness and learning voice.

3.0 METHODOLOGY

3.1 ADDIE Model and Development

ADDIE is one element of the educational system development. The chosen methodology is ADDIE model. ADDIE model is a starting method that has a systematic stream from the original basis. The systematic process is represented under the acronym ADDIE, which is a key component in the creation of education design such as analysis, design, development, implementation, and evaluation. The ADDIE model is selected because it sets out an obvious objective, structured content for learning, the utilization of a multimedia element, activities, and evaluations aimed at learning results. The software can be complemented with the analysis stage, layout stage, development stage, execution stage, and the ultimate assessment stage with the ADDIE model.

The ADDIE model for effective designs is one of the most usual models in the instructional design. This model is a strategy that supports education developers, developers of all objects or even educators in developing an effective learning strategy, using ADDIE procedures for every item of instruction. The learning environment and the existing knowledge and skills of the learner are established. The evaluation stage comprises of a collection of teaching objectives centred on a choice of skills, a concept map to handle the notion to attain the teaching goals and the course material arranged in modules (Sardan & Rias, 2013).

The design phase focuses on the objective of learning, content and exercise, assessment instrument, analysis of the subject matter, media selection and planning of lessons (Sardan & Rias, 2013). The phase of design needs to be precise, specific, and systematic. The development stage involves the creation and assembly of the content assets developed during the design stage. Chosen technologies need to be identified and integrated to enhance a learning experience. The instructions, media used in the instructions and supporting paperwork must be created during the implementation phase (Sardan & Rias, 2013). The actual provision of the instruction is identified during the implementation phase and a training process is established for educating and learning people. This stage helps learners to understand the content and promotes mastery of goals.

The teaching facilitators usually cover the curriculum, teaching results, distribution process and test processes (Abd Latih & Wan Ahmad, 2018). This phase contains two segments which are summative and formative. The overall efficiency of the directive is assessed and is generally assessed following the initial version of the instruction and generally after the initial version has been enacted. During and between stages, formative evaluations are continuous (Abd Latih & Wan Ahmad, 2018). Figure 2 and Figure 3 show the interfaces of the courseware and the example of the activities.

Figure 2 : Interfaces of MCDys

Figure 3: Drag and Drop Picture Activity

4.0 RESULT AND DISCUSSION

The courseware has been successfully developed to deliver a final product which is called Mathematics courseware for dyscalculia students. The purpose of developing this courseware is to learn about Mathematics for dyscalculia students. To help the students understand the courseware, all buttons are navigated and function well. Some of the buttons have an action button where the colour of the button will change when the user moves towards it which can help them to understand easier. Table 2 shows the comparison before and after courseware development. The elements that have been compared are method of teaching, module, and multimedia elements.

Table 2 Comparison Before and After Developed the Courseware

Element	Before	After
Method of teaching	Using whiteboard	Using computer to run the courseware
Module	Only used book to learn	Use courseware to learn and write the notes
Multimedia elements	Only use voice, text and graphic	Use all element to attract the audience.

User evaluation was distributed to give the result of the 10 constructs. The constructs consist of interface(A), usability(B), activity(C), navigation(D), theory of Schneiderman's eight golden rules of interface design(E), element of multimedia for sound(F), element of multimedia for image(I), element of multimedia for text(H), element of multimedia for multimedia for animation(I) and video(J). The highest mean of the 10 constructs is usability with the mean of 4.6(SD=0.55). Courseware testing was conducted by the developer to verify the overall system functionality. The test plan was used to document results. The performance of the device was then tested by two types of users including experts and other potential users. Three experts have validated the system usability and provide inputs for further enhancement. For user evaluation, 5 dyscalculia students have evaluated the courseware. The finding was recorded using a set of questionnaires. The highest mean is 4.25 and the lowest is 3.8. Figure 4 shows the result of Theory Schneiderman's Eight Golden Rules of interface design while Figure 5 shows the graph of the user evaluation's overall result.
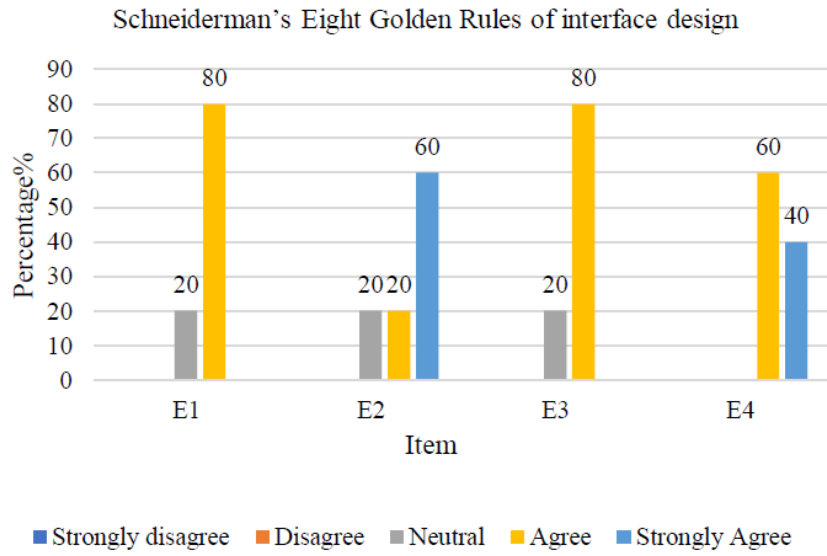
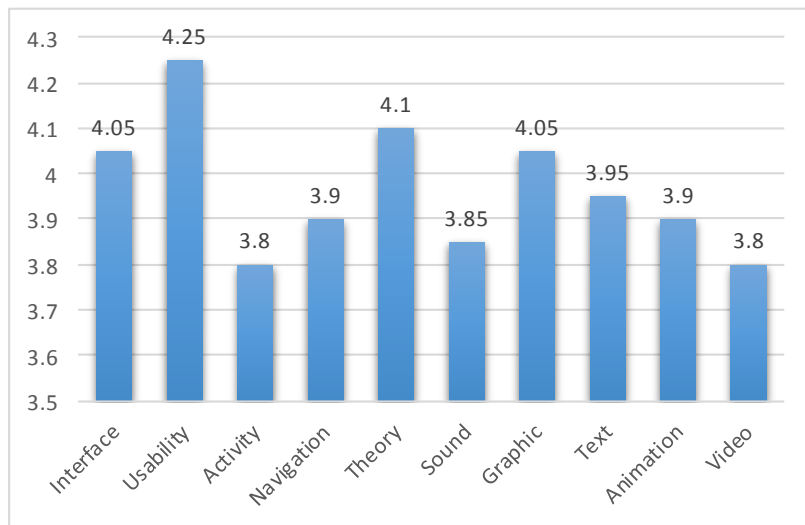**Figure 1: Result on Theory Schneiderman's Eight Golden Rules of Interface Design**

Figure 2: Graph for User Evaluation Overall Result

5.0 CONCLUSION

Mathematics courseware for dyscalculia students (MCDys) is a courseware that can help students who have difficulties in learning Mathematics. MCDys can help enhance their Mathematics skills and assist teachers when teaching as well as ease their tasks. In other words, MCDys can give advantages to both learners and teachers. By using this courseware, the learning process will be interactive. On the other hand, this courseware has several aspects which need to be improved and repaired for future enhancement.

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