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Nor Hasbiah Ubaidullah, Khairulanuar Samsudin, Jamilah Hamid, Saira Banu Omar Khan
Faculty of Art, Computing and Creative Industry,
Sultan Idris Education University, Perak, Malaysia.
hasbiah@fskik.upsi.edu.my
{khairulanuar, hjamilah, sairabanu}@fskik.upsi.edu.my

INTRODUCTION

Learning disability is a neurobiological disorder affecting the structuring and functioning of a person's brain. This mental condition affect a person's ability to speak, listen, read, write, spell, reason, recall, and reorganize information; and it poses a significant difficulty in learning mathematics (The Coordinated Campaign for Learning Disabilities, 1998). Among the common types of learning disability is dyslexia. Lokerson (2002) defined dyslexia as a severe difficulty in understanding or using one or more areas of language, including listening, speaking, reading, writing and spelling. Joffe (2005) found that dyslexic students would not only have trouble in reading, writing and spelling, but also in mathematics. The same researcher contends that a high proportion of dyslexic students – at about 60% – would typically face difficulties in learning mathematics, which raises serious educational implications. The various degree of severity of dyslexia further heightens this matter. There are several clues to diagnose children with dyslexia, but because each individual is different, not every child exhibits the same symptom (Baumer, 1996). Thus, dyslexic students would require extra support and motivation in learning, particularly for unfamiliar, new tasks. Various learning strategies have been conceptualized to help these students and invariably the application of technologies seems to be a major choice. One fine example is to employ a multimedia courseware, which is designed based on critical scaffolding principles that can help students with learning disabilities namely dyslexia (Barry & Pitt 2006; Jackson, Krajcik, & Soloway 2005).

Judge (2001), and Quintana and Fishman (2006) cautioned the lack of adequate research on multimedia courseware that integrates scaffolding principles into the courseware development as most of these were based on scaffolding designed for teacher (Lepper, Drake & O'Donnell-Johnson 1997; Wolery, Ault & Doyle 1992). Only a few research are related to scaffolding which focus on the design of digital learning environment for children. Beale (2005) states that interactive, digital multimedia can serve as an ideal platform for intelligent learning environment using scaffolding strategies. He also suggests a few learning concepts that were derived from the behavioural research literature, which is relevant to the design of scaffolding components in the digital learning environment. According to Beale (2005), errorless learning, knowledge or prerequisite skills, immediate positive feedback, motivation to learn, and cognitive loading are among the behavioural concepts deemed critical when designing a learning environment with scaffolding principles. In view of the lack of multimedia courseware with scaffolding strategy for use by dyslexic students, the need to develop such a learning tool grows more and more

imperative. Thus, the design, development and application of a multimedia courseware (i.e., multiplication module) with scaffolding strategy have been carried out by the researchers to address the prevailing learning issues faced by the dyslexic students. Two main research objectives to set the direction and aims of the study are as follows:

(a) To develop a multimedia courseware (i.e., multiplication module) using scaffolding strategy and Mnemonic V-A method that can help dyslexic students to learn multiplication,
(b) To evaluate the usability (i.e., flexibility) of the multimedia courseware as perceived by the dyslexic students.

The main focus of this study was on the learning problems experienced by eight (8) dyslexic students of a special dyslexic school in Titiwangsa Kuala Lumpur, Malaysia in learning multiplication table (Multiplication tables 1-5).

SCAFFOLDING MODEL

A scaffolding model is an important model or tool that can help dyslexic students to improve their mathematical literacy. Scaffolding models (multiplication tables 1-5) have been developed and integrated into the courseware (multiplication module) in order to assist dyslexic students learn multiplication tables effectively, and at the same time to motivate them in the learning process. Integrating scaffolding into the courseware would assist learners in learning through appropriate support that gradually increases learning independence (Torgeson 2004). Eight scaffolding models for multiplication for number one (1) to number five (5) have been developed to assist the dyslexic students. The models are based on two main strategies: Strategy 1 and Strategy 2, which are summarized in Table 1.0.

Table 1.0: Strategy models for the multiplication module

Strategy:	Description:	Model name:
Strategy 1a	Scaffolding model for multiplication with number 0	MSDN-0
Strategy 1b	Scaffolding model for multiplication with number 1	MSDN-1
Strategy 1c	Scaffolding model for multiplication with double numbers	MSDN-2
Strategy 1d	Scaffolding model for multiplication with number 5	MSDN-5
Strategy 1e	Scaffolding model for multiplication with number 9	MSDN-9
Strategy 1f	Scaffolding model for multiplication with number 10	MSDN-10
Strategy 1g	Scaffolding model for multiplication with number 11	MSDN-11
Strategy 2	Scaffolding model for multiplication of numbers in pegword category	MSDN-PegW

Example of the scaffolding model related to Strategy 1 is shown in Figure 1.0. Scaffolding model for multiplication with number zero consists of several elements: (i) category of number, (ii) strategy chart, and (iii) method in gaining an answer. The category of the number in the

strategy refers to number zero; the strategy chart refers to the rule or procedure that has to be performed by the system, which is based on student's response; and the method in gaining an answer refers to how to get an answer through an example. Figure 1.0 shows the model used in the study.

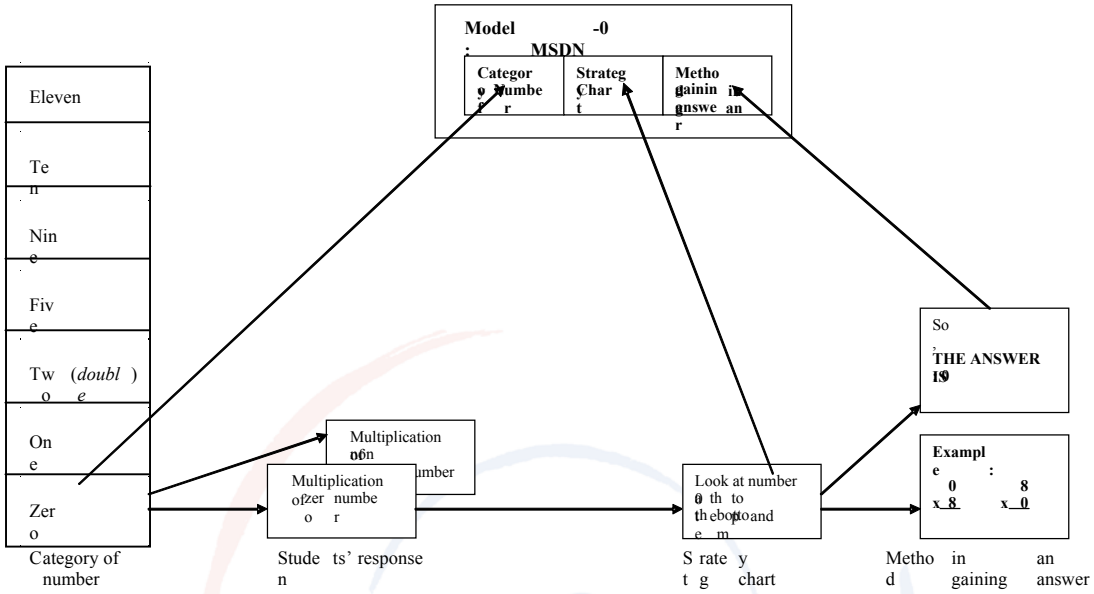


Figure 1.0: Strategy 1 - Scaffolding Model for multiplication with number 0 (MSDN-0)

THE DEVELOPMENT OF THE MULTIPLICATION MODULE

The development of the multiplication module has been carried out to assist and motivate dyslexic students in learning the multiplication table. The targeted group comprised a standard four dyslexic student (i.e., a fourth grader) of the special dyslexic school in Titiwangsa Kuala Lumpur and other seven dyslexic students. The module could also serve as an alternative learning material in learning multiplication table for the targeted dyslexic student as well as other dyslexic students. The multiplication module has been packaged into the CD format. The screen shot for the introduction of the module is shown in Figure 2.0.

The multiplication module comprises three sub-modules: *Belajar* (Learning), *Latihan* (Exercise) and *Aktiviti* (Activity) as depicted in Figure 2.0. The contents of the multiplication table were presented in the Malay language to suit the needs and syllabus requirements of the participant.

Sub-module *Belajar Darab* (Learning Multiplication Table) was designed for the purpose of learning multiplication tables of numbers ranging from one to six using scaffolding strategy and Mnemonic V-A method. Mnemonic V-A method consisted of two steps which were *Langkah 1* (Step 1) and *Langkah 2* (Step 2). In *Langkah 1*, it involved the numbers such as 0, 1, double (2,2), 5, 9, 10 and 11; meanwhile in *Langkah 2*, it involved the numbers in *pegword* category, meaning that the numbers which were not involved in *Langkah 1*.

Figure 3.0 shows the first screen in sub-module *Belajar Darab*. The screen introduces the Mnemonic V-A method to the dyslexic students using an approach of mind maping concept. Hence, it could help dyslexic students gain the overall view regarding what they will learn. On top of that, the integration of multimedia elements such as animation, text and audio were presented in an interesting way, in order to encourage dyslexic students to explore the following screen.

Meanwhile Figure 4.0(i) to Figure 4.0 (v) are examples of screen for demonstrating multiplying number of category 9 in *Langkah 1*. These screens show the technique of memorizing multiplication table of 9 using Mnemonic V-A method.

Figure. 2.0: The selection icons of the Multiplication Module

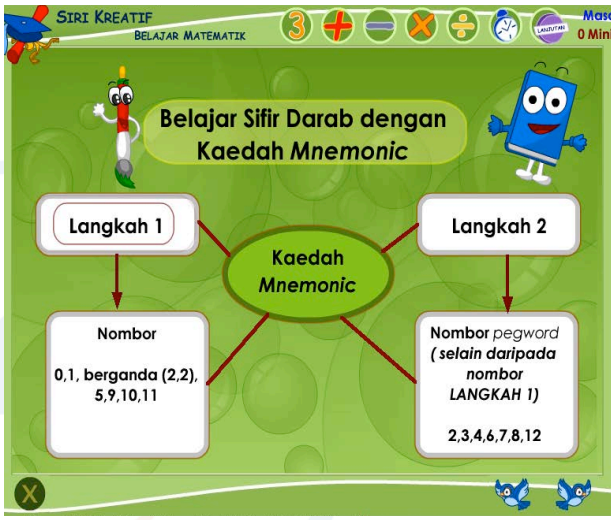


Figure 3.0: The Mnemonic V-A method in sub-module Belajar Darab

The screen shot for one of the exercise in the *Modul Darab Nombor* (Multiplication Module) is shown in Figure 5.0. The participant was required to answer a given question and then the system would respond accordingly to provide the correct solution. The pupil used the scaffolding approach as a problem solving aid, which is based on the scaffolding model discussed earlier. By integrating the model into the module, the system would be able to assist the dyslexic student in solving a series of multiplication problems within the stipulated phase. Figure 5.0 has also integrated the Scaffolding model aspect through preparing an appropriare answer selection, and based on dyslexic students' response to the system.

Figure 4.0(i) First Screen of *Langkah 1*: Number 9 Category

Figure 4.0(ii) Second Screen of *Langkah 1*: Number 9 Category

Figure 4.0(iii) Third Screen of *Langkah 1*: Number 9 Category

Figure 4.0(iv) Fourth Screen of *Langkah1* : Number 9 Category

Figure 4.0(v) Fifth Screen of *Langkah 1*: Number 9 Category

Figure 5.0: Screen sub-module *Belajar Modul Darab Nombor* based on Scaffolding model

This research has produced a mathematics courseware for dyslexic students where its content and interface were found to be well accepted by the pupils. The dyslexic students were very excited and inspired to learn mathematics owing to the interactive and appealing elements of the courseware namely the flashy question pop-ups, animation, colourful background, prompt feedback of answers and audio narration.

After the completion of the multiplication module by the dyslexic student, a flexibility test was conducted where the multiplication module was again given to the same student, and student's feedback was obtained after three months. The frequency of use of the multiplication sub-modules of the multiplication module by the student serves as the measure of the flexibility of the learning tool.

METHODOLOGY

This study was based on the design and development research "… [involving] the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development" (Richey & Klein, 2007). The development of the multiplication module used the courseware engineering principles involving the integration of Instructional Design Methodology (ADDIE model) and Software Development Methodology (Rapid Prototyping). According to Bostock (2003), courseware engineering is a mix of two well-established disciplines: software engineering as the process of developing business software, and the instructional design as the process of developing instruction for delivery by computers or other means. The combination of the development, implementation, evaluation phases and prototyping process is shown in Figure 6.0. Qualitative data to test the flexibility aspect of the D-Matematika courseware were gathered based on an ethnographic method through observations.

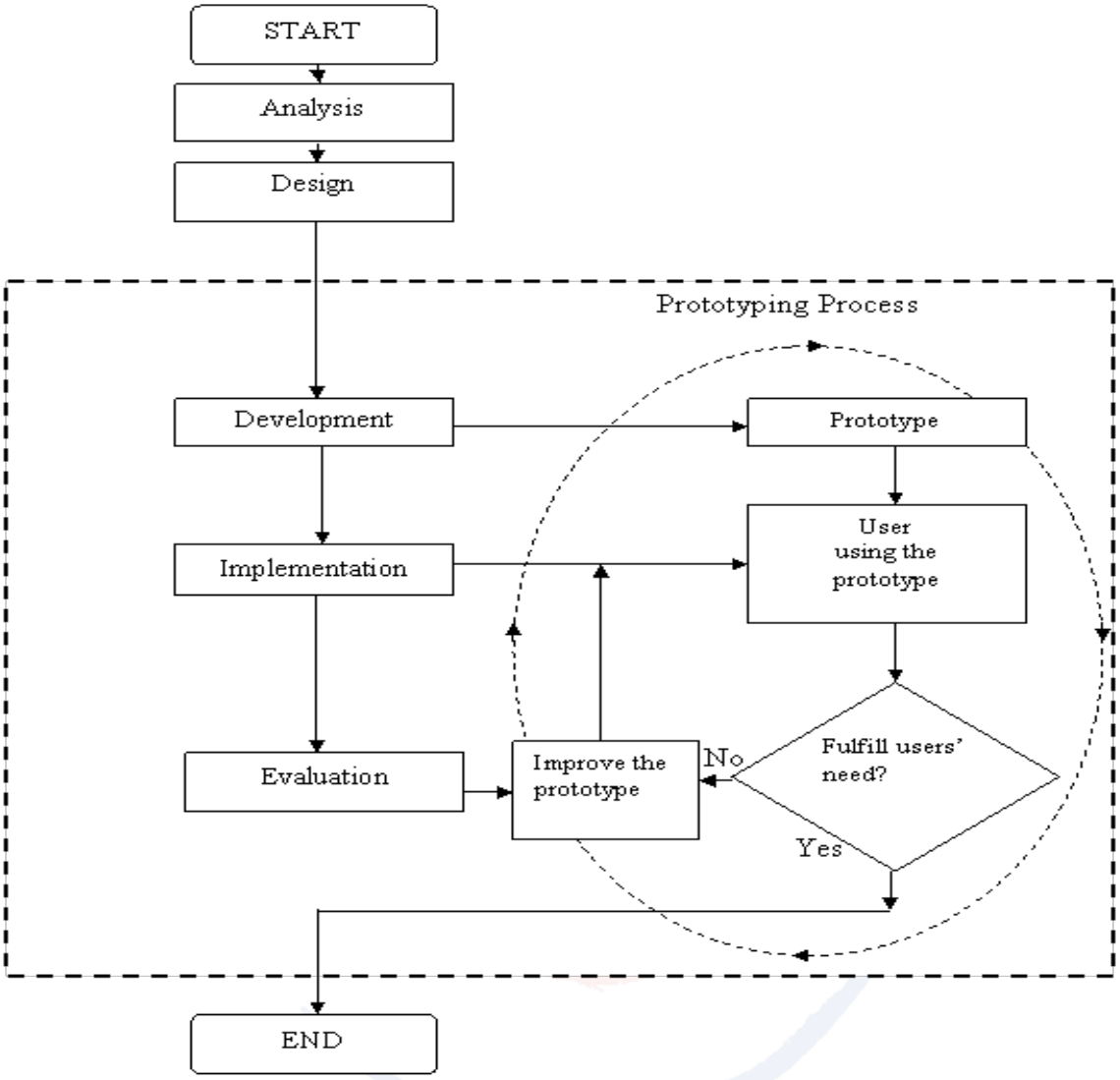


Figure 6.0: A combination of development, implementation, evaluation phases and prototyping

Respondents

As for the observation, eight (8) dyslexic students were drawn from the special dyslexic school in Titiwangsa, Kuala Lumpur. They mean age was eight (8) years and their academic achievements were approximately similar as informed by their teachers. Parental consent was secured from respective parents prior to the observational exercise.

This relatively small sample size comprising eight pupils is within the recommended values as the evaluation of a prototype especially for use by students with learning disability is normally performed through a small sample size (Gagne, Briggs, & Wager, 1992; McKethan & Everhat,

2001). This standpoint is practical to test the effectiveness and usability of a software in detail before a complete, working software is developed. According to Virzi (1992), a sample of 4-5 pupils is enough to identify 80%-90% of learner's usability problem, especially for learners with learning problem. In assessing the effect of a teaching package in solving a multiplication problem, Wood, Frank, and Wacker (1998) used only three students and managed to obtain detailed and useful findings. With eight pupils, this study would be able to reveal findings pertaining to the flexibility construct of the multimedia courseware that are adequate and reliable.

Research Instrument

The main instrument used by the researchers in the study was based on a checklist known as the *Senarai Semak Matematik Ujian Keanjalan* – (*SSMUK*) for dyslexic students. Learning activities performed by the dyslexic students were meticulously observed and recorded.

Data Gathering/ Research Procedure

The research procedure was conducted based on two phases as follows:

Phase 1: Obtaining written permission from the chairperson of the special dyslexic school in Titiwangsa Kuala Lumpur and parents of the dyslexic students before the implementation of the observation.

Phase 2: Working with the selected dyslexic students. An ethnography method was used in this study to test the flexibility aspect of the courseware based on the frequency of use of the multiplication module through a check list. Throughout the learning activities, the researchers managed and overlooked all the interactions and observations with the assistance of the teachers who taught these students.

Data Analysis

The ethnography method was used to analyze the observation and the interaction with the dyslexic students. The frequencies of use of the sub-module *Belajar* (Learning) were recorded in order to gauge and measure students' improvement. The participants were observed four times spanning three months namely first, fifth, tenth and twelfth weeks.

RESULTS AND DISCUSSION

The results show a gradual decrease in the use of the multiplication sub-modules over this period of observation. The first participant used the multiplication sub-modules thrice on the first observation (week-1), twice on the second observation (week-5), only once on the third observation (week-10) and he did not use the module at all on the fourth observation (week-12). The table also shows that the third student (S3), the sixth student (S6) and the eighth student (S8) did not use the module at all on the fourth observation (week-12). Even though the results show students S2, S4, S5 and S7 had used the multiplication sub-modules once on the fourth observation (week-12), a gradual decrease in the use of the multiplication sub-modules over this

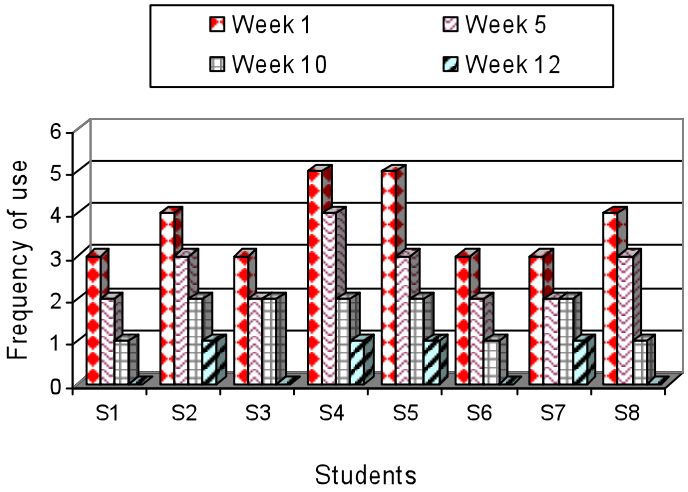
period of observation was quite apparent. Table 2.0 summarizes the frequency of use of the multiplication sub-module by the participants over this period.

As expected, the use of the multiplication module's *Belajar* (Learning) was quite high beginning the earlier phase of the learning process. The frequency of use of this sub-module dropped slightly on the fifth week and continued to decline gradually on the tenth week. Eventually, the participant did not resort to using this sub-module when performing the rest of the activities in this study namely the *Latihan* (Training) and *Aktiviti* (Activities) sub-modules. Evidentially, the participant had gained sufficient level of understanding of the multiplication concepts that eventually weaned them the scaffolding feature of the multimedia courseware. This particular finding shows that the multiplication module is promising and highly flexible through the scaffolding approach (i.e. the fading characteristic).

The purpose of the scaffolding approach was to give an indirect support to the dyslexic student making him more comfortable and confident with himself. Pahl (2002) also supports the integration of scaffolding approach into the courseware development where users will gradually become less dependent of this cognitive support as they become more confident in performing the tasks. The scaffolding model developed was demonstrated to be flexible in fulfilling the needs of the dyslexic student in learning multiplication operations. The result of the study concurs with Tinker's (2001) analogy that likens the software to the scaffolds of a construction site that are readily adjustable to individual needs – as when desired and required.

Table 2.0: Frequency of use of the multiplication sub-modules

Activity	Week	Frequency of use							
Students		S1	S2	S3	S4	S5	S6	S7	S8
First observation	1	3	4	3	5	5	3	3	4
Second observation	5	2	3	2	4	3	2	2	3
Third observation	10	1	2	2	2	2	1	2	1
Fourth observation	12	**Nil**	**1**	**Nil**	**1**	**1**	**Nil**	**1**	**Nil**



In many instances in Malaysian schools, most teachers use an array of multimedia courseware that were developed by the Curriculum Development Centre; and invariably these learning tools are primarily designed for normal students. However, these software lack instructional strategy for teaching dyslexic students where the need for scaffolds is imperative for meaningful learning (Nor Hasbiah, 2007; Sri Fatiany Abd Kader & Ismail, 2008, Zainuddin et al., 2009).

Due to their limited cognitive ability, dyslexic students would face problems in understanding the multiplication table concepts introduced to them. Retention of knowledge is also compromised, as they do not posses well-developed working memory (Nor Hasbiah, 2007) which concurs with another finding affecting deaf students (Zainuddin et. al., 2009). Hence, the integration of the Mnemonic V-A method in the courseware could act as a cognitive tool for helping dyslexic students in recalling information

In light of this dire situation, the finding of the study provides a strong case for instructional designers and developers to invest more effort in developing specific, customized learning tool for disadvantaged pupils. This will help create a learning environment that is conducive and supportive through computer-mediated scaffolds to improve the learning process, which is challenging in many learning domains, particularly in mathematics.

CONCLUSION

This study provides evidence that the integration of scaffolding approach and mnemonic V-A method into a multiplication module is efficacious in helping dyslexic students to learn multiplication operations. The multiplication module based on this design can serve as an effective learning tool where students with dyslexia will be supported through computer-enhanced scaffolds. These scaffolds serve as a very crucial cognitive support especially during the early phase of the learning process of the multiplication exercises. However, several improvements need to be addressed in developing future learning module. These include the

addition of the multiplication tables of numbers ranging from six to 12 into the module. Greater sample size of dyslexic participants is entailed to improve the validity of the test results and the views of the experts can be sought to shed more insights on the learning of mathematical operations. Overall, this study has revealed promising result that can further enrich the body of knowledge pertaining to the learning of students with dyslexia symptoms.

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