Interactive Mathematical Learning Courseware 2. 0 Using Mental Arithmetic for Preschool Children

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Abstract

Interactive Mathematical Learning Courseware 2.0 (iMLc 2.0) is an enhanced version of multimedia application which the aim is to expose the pre-school children in mental arithmetic technique. Unlike other form of conventional application which are using traditional methods, iMLc 2.0 display highly efficient technique to users who are at early stage of learning mathematics. The application integrates multimedia elements and mental arithmetic technique in an interactive and supportive way that is suitable for pre-school children level. Six multimedia principles have been adapted into the application in order to enhance the interface design. The application is divided into three modules, addition, subtraction, and quizzes. The addition operation has been designed to apply the finger-brain approach which is part of mental arithmetic technique while, mental-imagery approach is adapted for subtraction operation. In order to evaluate the application, it goes through a series of testing which are experimental test and user acceptance test. Mathematical courseware application can be used as additional learning and teaching tools since it is interesting, user friendly, enjoyable, valuable, and supportive. The implementation of iMLc 2.0 using interactive multimedia environment can motivate the preschooler to be prepared for future mathematical learning.

Keywords: Mental Arithmetic Technique, children's learning preferences, cognitive thinking, principle and elements of multimedia.

Introduction

The process of learning mathematics, such as numbers and basic operations like addition and subtraction, takes a long time to build for new learners, especially for pre-schoolers. They also find it hard to memorize the numbers and the mathematical concepts even though they already know and understand them. Currently, technology is used and computer is one of the main aspirations and is integrated in education curriculums (Ktoridou, Eleokleous & Gregoriou, 2005).

With the evolution of computer technology, learning of mathematics for pre-school children can be improved with the help of multimedia tools in order to attract their attention and interest. Furthermore, the children are already exposed to computer at an early age.

Multimedia is an interactive computer-based environment with the combination of texts, voices, pictures and animations (Weiss, Kramarski & Talis, 2006). Thus the teachers can teach more consistently and effectively by using it as an alternative teaching tool. This is different from the traditional method, where only the exercise book is used as their single source in learning mathematics because of lack of tools. This results in a boring environment and tends to make the children lose their focus.

Mental Arithmetic Technique can help the children to build cognitive thinking when they need to use mental representations and fingers in order to do basic operation exercises. With the support of multimedia, their imagination of the mathematical concepts can be at higher levels. This improves their performance and allows them to be more active and excited by using the combination of multimedia elements during learning sessions.

Mental Arithmetic Technique

Mental arithmetic can be defined as the action of adding numbers together, multiplying them and other mathematical operations by using the brain, without writing them down on a piece of paper or the use of calculators (Longman, 2010). This technique is usually used in mathematical operations such as

simple addition, subtraction, multiplication, and division.

Mental arithmetic is also one of the methods that use the movement of fingers for counting numerical values (Wu, Meyer, Maeda, Salimpoor, Tomiyama, Geary & Menon, 2008; Klien, Moeller, Wilmess, Nuerk & Domahs, 2011) as well as the working brain. For instance, Cheah‟s study (as cited in Ahmad, Rosmani, Ismail & Mohammad Shakeri, 2010) states that children move their real fingers to start the counting process after they build their imagination in the brain.

Children's Cognitive Thinking

According to Longman (2010), cognitive or mental processes are the processes of recognizing, understanding, and learning something. The evolution of technology must be parallel to the development of children's cognitive thinking and skill to make sure that they are able to communicate to the real world in future.

According to Gelderblom and Kotze (2008), cognitive skills in children can be sharpened through interaction and communication with computers. Based on Piaget's Theory, children around five to eight years old are able to obtain the skills about objects, events, people, and use the symbols to imagine and represent real life and some examples are the symbols of words, numbers, and images.

Multimedia

Multimedia is defined as the interactive computer-base, which is included with the texts, images, audio, video, and animations (Shujuan, Wei, Zheng & Qibo, 2010; Weiss et al., 2006; Segers, Verhoeven & Hulstijn-Hendrikse, 2008; & Ahmad et al., 2010). The use of multimedia is able to attract the children's interest and attention towards learning mathematics.

A. Elements in Multimedia

An interactive multimedia is composed of many elements that are important to deliver attractive prototype to children's learning. Animation is primarily used to illustrate the ideas and concepts. At an early age, children usually like to learn from the moving images because of their characters, which are attractive and motivating (Betrancourt & Chassot, 2008). Animation is essential to improve understanding and brings out the interests of young learners (Fang et al., 2009; Betrancourt & Chassot, 2008). Other than that, images or graphics are considered to be part of multimedia where creativity and imagination are needed in a learning session. The use of graphics can help to sharpen their memory (Betrancourt & Chassot, 2008) and stimulate mental model representations (Betrancourt & Chassot, 2008; Ali & Badioze Zaman, 2006).

The audio or sound also assists the children to give optimum attention and provides a way to learn mathematical concepts or terms from the oral speech. According to Ali and Badioze Zaman (2006), the implementation of sound can improve learning and pronunciation skills after listening to the spoken explanation. Besides that, text also is the element that is important in providing interaction and information. Segers et al. (2008) also support that the written text makes multimedia an effective way to communicate. Moreover, video is also a multimedia element.

B. Principles of Multimedia

In order for the multimedia effect to have an interesting and attractive design, the Principles of Multimedia that are proposed must be followed. There are seven Principles of Multimedia: (1) Multimedia; (2) Spatial Contiguity; (3) Temporal Contiguity; (4) Coherence; (5) Modality; (6) Redundancy and (7) Personalization. The first Principle is Multimedia, where the children are more likely to learn from the use of words and pictures rather than from single words alone because it can result in deep and better understanding (Mayer & Moreno, 2002; Mayer, 2003). Through the Spatial Contiguity Principle, they also state that learners deeply focus during the learning session when the corresponding text and pictures are presented closely to each other rather than in distance.

The third principle is about temporal contiguity in which the children get better explanation from the corresponding text and graphics in simultaneous presentations rather than consecutively, as is stated in the research by Mayer and Moreno (2002). Young learners are able to learn more deeply and improve their memory when irrelevant materials of words, pictures and sounds are excluded from the learning session according to the Coherence Principle (Mayer & Moreno, 2002; Mayer, 2003). Furthermore, they find that the fifth principle, Modality, is where the children generate more problem-solving and deeper cognitive thinking skills with the adaptation of animation and narration rather than animations and on-screen texts.

They also state that the sixth principle, Redundancy, occurs when a learning session with animations and narrations is preferred to animations, narrations and on-screen texts because additional on-screen texts limit the visual working memory. The last principle is Personalization, where the children learn deeply when words and animations are in conversational style rather than formal style (Mayer & Moreno, 2002; Mayer, 2003).

Methodology

The study was conducted by applying research model as depicted in Figure 1. There were three main phases involved in the activities which are: 1) Analysis, 2) Design & Construction, and 3) Testing & Evaluation.

A. Analysis Phase

The first phase involved collecting information on three area of studies; preschoolers' preferences, multimedia elements principles and mental arithmetic. Interview sessions and observation technique was conducted to gain insight of the target users and the classroom environment. For interview sessions, two pre-school teachers in Kedah were selected and observation was performed during preschoolers' mathematics classes. The observation was focused on the execution of mathematic classes, children's behaviors and reactions towards learning process.

B. Design and Construction Phase

The second phase consisted of two main activities; design and construction. Designing activity involved storyboard preparation, where interface design concept was sketched. This was based on information gathered from the previous stage. The following process was to design user interface that incorporated multimedia elements such as graphics, sounds, texts, animations and videos using Adobe Flash, Adobe Photoshop and Adobe Illustrator software. Those elements were carefully chosen to stimulate the children's learning experience and to entertain them. Next, the design was translated into multimedia application in construction activity. This activity consisted of scripting and integration of the designed user interface. The main tasks of construction activity were done using Adobe Flash, Audacity and AVS Video Editor Software. Finally, this phase was accomplished by a multimedia application prototype named as Interactive Mathematical Learning v2.0 (iMLc v2.0) as the deliverable.

C. Testing and Evaluation Phase

The final phase engaged a series of testing and evaluation processes. The prototype was tested using usability testing and some refinements were done on the prototype based on the users' comments. Next, experimental testing which were Pre-Test and Post-Test evaluation were conducted to measure the children's performance. During Pre-Test session, the children were provided with mathematic questions and they have to resolve the questions using their normal learning process. Whereas during Post-Test session, they were asked to answer a different set of question but this time by applying mental arithmetic learning process. An acceptance test was conducted with kindergarten teachers in order to assess courseware's acceptability among the targeted audiences. They were given a set of acceptance test questionnaires consisted of 13 Likert Scale Based questions. Results from the test were analyzed to determine the acceptance rate of the application.

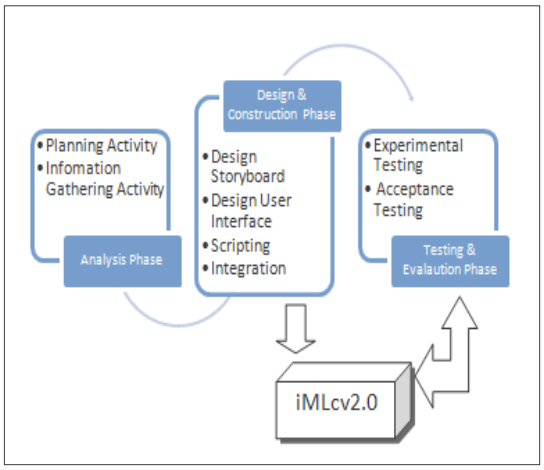

Figure 1: Research Model

COURSEWARE ARCHITECTURE

Mathematical Courseware application consists of three main menus: 1) Number, 2) Operation, and 3) Activity modules. Figure 2 shows Mathematical Courseware application architecture.

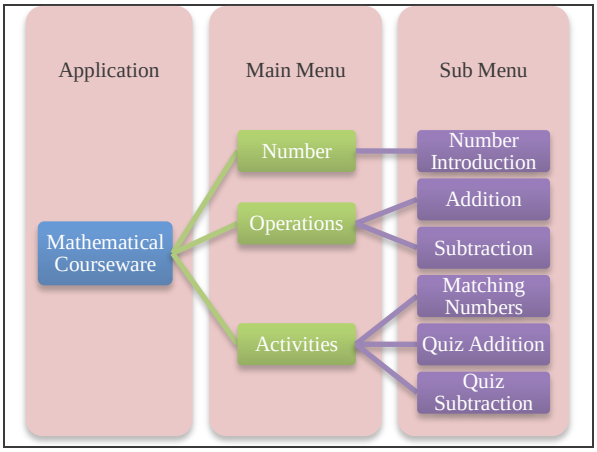

Figure 2: Mathematical Courseware application architecture

i. Number

Number menu consists of Number Introduction sub menu as shown in Figure 3. The children can learn starting from number one until number nine. This menu also was provided with the animation object and spelling that represents the numbers.

Figure 3: Number Introduction Interface

ii. Operation

There are two sub menu involved in the operation menu of the application. They are addition and subtraction operation. Figure 4 shows the addition interface which applied mental arithmetic technique and provided with the video for addition process. While Figure 5 shows the subtraction operation interface.

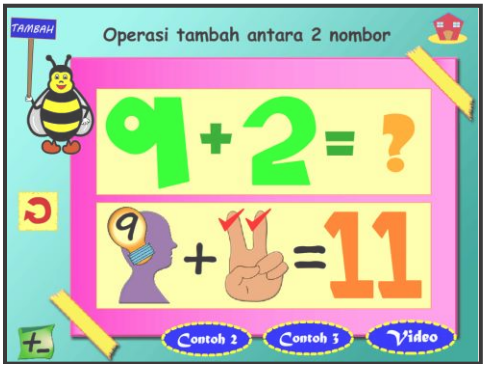

Figure 4: Addition Operation Interface

Figure 5: Subtraction Operation Interface

iii. Activity

Activity menu consists of three different sub menus which are matching number, addition quizzes and subtraction quizzes. The concepts that were applied in the activity menu are drag and drop, perfect choice and writing concept. One of the activities is shown in Figure 6, matching number activity, which use drag and drop concept.

Figure 6: Drag and Drop Interface

Finding And Discussion

Experimental Test and User Acceptance Test were conducted during testing phase of the application. Experimental Test was done with 40 preschoolers in two schools in Kedah to measure their level of understanding towards the application by carried out pre-test and post-test. The level of understanding for both schools were represented by the mean score of pre-test and post-test as shown in Figure 7. Children were found to be able to achieve higher scores after being exposed with the mental arithmetic technique. The time taken for the children to solve the mathematical problem also decreases noticeably as it only took 5 to 10 minutes to complete all questions compared to almost 15 minutes by children being taught with the traditional method

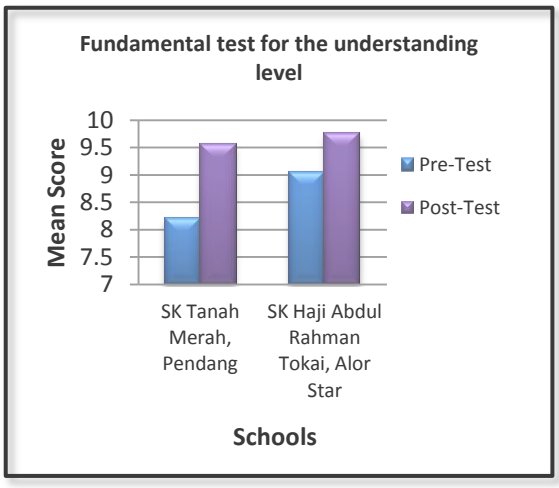

Figure 7: Comparison of understanding level for pre-test and post-test

User Acceptance Test was conducted with seven preschool teachers in order to determine the confidence level of end users of the application and to ascertain whether it can be accepted as a teaching tool in preschool. They were given time to explore the application before answering a set of questionnaires that covers four criteria. They are Perceived Ease Use

(PEU), Perceived Usefulness (PU), Attitude (ATT), and Intention to Use (BI). Mean score for all criteria were calculated and plotted into a bar chart as shown in Figure 8 below.

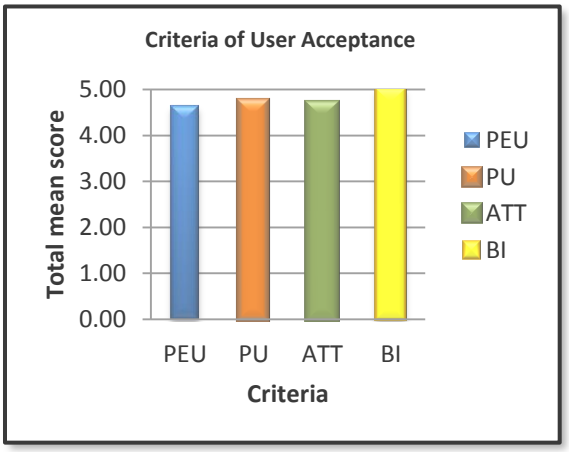

Figure 8: Bar chart of criteria for user acceptance test

II. Conclusion

Based on this study, it can be summarized that the Mathematical Courseware application was successfully accepted to be used in teaching and learning mathematics in preschool. The children's understanding in mental arithmetic technique is believed to have increased as they could visualize the techniques in a better way, which is using the video element rather than using animation alone. This is because learning mathematics through multimedia application can increase excitement and interest during the learning session.

The application has achieved its target to be a helpful tool in improving user performance and sharpening their cognitive thinking. This technique could possibly implement in different schooling levels for example in pre-school, primary school (lower and higher level) and secondary school. However, the approach for each level should be different.

In conclusion, this application has achieved the objectives of this research, where an Interactive Mathematical Learning Courseware was designed and developed by adapting suitable multimedia elements such as text, graphics, animation, sound, and video. The Mental Arithmetic Technique was also successfully implemented and introduced in the application. Thus, multimedia application is one of the tools that could delight children in their study.

REFERENCES

Ahmad, S. Z., Rosmani, A. F., Ismail, M. H., & Suraya, M. S. (2010). An Introductory of Mental Arithmetic Using Interactive Multimedia. *Computer and Information Science , 3* (4), 72-79.

Ali, B. B., & Badioze Zaman, H. (2006). Framework of Adaptive Multimedia Mathematics Courseware. *Proceeding of the 2nd IMT-GT Regional Conference on Mathematics, Statistics and Applications.* Penang.

Betrancourt, M., & Chassot, A. (2008). Making Sense of Animation: How Do Children Explore Multimedia Instruction? Cognitive Processes in Children's Multimedia Text Learning. (2008). *Applied Cognitive Psychology , 22*, 375-387.

Gelderblom, H., & Kotze, P. (2008). Designing Technology for Young Children: What we can Learn from Theories of Cognitive Development. 66-75.

Klein, E., Moeller, K., Willmes, K., Nuerk, H.-C., & Domahs, F. (2011). The influence of implicit hand-based representations on mental arithmetic. *Frontiers in Psychology | Cognition , 2*, 1-7.

Ktoridou, D., Etekleous, N., & Gregoriou, G. (2005). Preschoolers Developing Mathematical Understanding through Computer-Based Activities. 787-790.

Longman. (2010). *Longman Dictionary of Contemporary English Online*. (Pearson Education Limited) Retrieved October 2011, from http://www.ldoceonline.com/

Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction , 13*, 125–139.

Mayer, R. E., & Moreno, R. (2002). Animation as an Aid to Multimedia Learning. *Educational Psychology Review , 14* (1), 87-99.

Shujuan, Z., Wei, S., Zheng, L., & Qibo, H. (2010). The Principles of Multimedia Teaching Design Based on Cognitive Load Theory. *2010 2nd International Conference on Education Technology and Computer (ICETC)* (pp. 110-112). IEEE.

Weiss, I., Kramarski, B., & Talis, S. (2006). Effects of multimedia environments on kindergarten children‟s mathematical achievements and style of learning. *Educational Media International , 43* (1), 3-17.

Wu, S. S., Meyer, M. L., Maeda, U., Salimpoor, V., Tomiyama, S., Geary, D. C., et al. (2008). Standardized Assessment of Strategy Use and Working Memory in Early Mental Arithmetic Performance. *Developmental Neuropsychology , 33* (3), 365-393.