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E-WAYCOOL: EMBEDDING IXD THEORY AND REPRESENTATION CONCEPTS IN TEACHING MATHEMATICS

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ABSTRACT

This paper introduces the use of the theory of interaction design (IxD) and the concept of representation in shadow play, known as Wayang Kulit (WK), to teach mathematics. Drawing from the facts that there is deficient in performance of primary school children in mathematics, we proposed the e-WayCool as a means for natural developmental progress in learning the subject. For teachers, e-WayCool provides options for a different version of a digital teaching tool to support teaching mathematical operations, namely addition, subtraction, multiplication and division whereby pre-algebraic concept is being introduced via the concept of representation. Ten actors of WK are utilized in delivering the teaching modules of the operations within the range of whole numbers ranging from 1-1000. Each operation is not mutually exclusive, but bound to a specific representation concept and activity scenarios. The results are discussed in terms of the interests and effectiveness of e-WayCool as a complementary digital tool for classroom instruction and, at the same time preserving the WK, one of the Malay endangered cultural heritages.

Keywords: digital wayang kulit, wayang kulit, representation concept, IxD theory.

INTRODUCTION

Several years ago, the National Council of Teachers of the United States included in its Standards that the computer technology applications should be used as one of the essential tools in learning and teaching (L and T) of mathematics (Syi, 2009). When time goes by, mathematics teachers have involved the use of applications or courseware in their teaching and many of them have developed various innovative ways of using multimedia technology to make their classroom more effective and efficient. The use of coursewares in a classroom would make it possible for students to venture many more practical features of mathematical operations (addition, subtraction, multiplication, division) behind their numbers and operators. Courseware too, would allow students more opportunities to perform hands-on exercises.

The use of courseware in classrooms may in general raise students' interest in mathematics and enhance their problem solving skills. Hence, the process of understanding is higher. Some other researchers indicate that students' posture and interest in learning science and mathematics is seen to be declining as they move from primary to secondary and then higher education level (Romli, Shiratuddin, and Hashim, 2003).

Taking up the problem, this paper proposes a representation conceptual model for teaching mathematics in primary school using animated two dimensions (2D) WK as a feature of 'game' in the concept. The model combines the actors of WK with the contents of mathematics subject (level one). The aim is to help create effective L and T environment that will enhance mathematics learning and at the same time preserve WK, a cultural heritage of Malaysia from slowly vanishing (Jasni, Zulikha, and Mohd-Amran, 2012). WK needs new alternative in the media output, to be digitalised into the e-world and to be watched on the computer screen or cinema (Ghouse, 2009).

Why WK and why mathematics?

According to Wahju (2014), the function of 'Wayang' can be compared to a picture book. It enables the children to adopt many distinct characters and to act out moods, conflicts and imaginative fiction in a safe environment. Moreover, there is a close relation between imagination and thinking ability.

It is the major aim of mathematics education in the Malaysian context, especially at the primary school level, to provide platform for critical and creative thinking. According to Jordan and Levine (2009), at an early age, competencies of basic numbers among students are shaped. This is supported by Kelanang and Zakaria (2012) where he reasoned that mathematics subject is difficult to learn, and students will have problem in symbolic number knowledge which is influenced by experience and teaching. Moreover, absence of concept formation and difficulty in remembering basic facts cause students not being able to solve problems (Kelanang and Zakaria, 2012). In addition, Bryant et al. (2008) mentioned that students who have difficulties in basic mathematics skills and concepts will face challenges in the basic arithmetic. This is supported by Dowker (2005) whereby he conferred a few situations or types of arithmetic difficulties showed by students. There are students who do not have problem in remembering number but lack of strategy to solve calculation problems. On the other hand, there are also students who are able to solve single digit arithmetic but face difficulty in understanding and mastering concepts of ones, tens, and place value.

Furthermore, research finding by Kelanang and Zakaria (2012) points towards students miscarriage in mastering the basic mathematics concepts (addition,

subtraction, multiply, division) will affect the ability in attaining mathematics skills at advanced level (secondary school).

The need for a better tool

This research paper presents the 'Electronic Wayang Kulit' (e-WayCOOL). The motivation for the research is based on the current challenges faced by Malaysia's primary students to learn and understand the concept of mathematics operations, and also by educators to teach mathematics using conventional and traditional means. Loftin et al. (1999) and researchers at the Johnson Space Centre, as stated by Seth (1999) believe that a new approach in mathematics and science education is needed. Furthermore, Loftin stated that so many students left by the wayside when it comes to traditional mathematics and science education. By the next level of education (secondary school level), the vast majorly of students have lost interest in these subjects.

The e-WayCOOL proposes a new representation concept with interaction (IxD) design theory to assist L and T practices. One of the main features of the e-WayCOOL was the ability to display WK performance in digital form. Conversely, the majority of the DWK available in the Malaysian market only focuses on the WK components without incorporating them with their subject matter, such as the mathematics operations. Presently, WK has never been used for any L and T activity. Rather, it is merely used for entertainment or traditional storytelling ('penglipurlara).

It is hoped when DWK courseware is introduced as one of the tools in the Malaysian education system, the outcome of the research will be invaluable in assisting the growth of the government's education project for primary school.

USING e-WayCOOL IN TEACHING ALGEBRA

The concept of representation is projected in learning modules intentionally to create the T and L process. The scope of e-WayCOOL only focuses on numbers between 0 to 1,000 and math's operation, which is addition, subtraction, multiplication, and division. E-WayCOOL has been used to teach mathematics subjects more effectively and makes the learning process more interesting. In the following section, we present the formula used in the concept of representation.

Addition operation

As an example of addition in visualization component in e-WayCOOL is shown in (1). It can be used in the rest of other four components in WK environment. In general, an addition function has the form

(0, 1000]
(0, 1000] (1)

whereinteger number with . is refer to the numbers of actor that will assigned with certain values in between 0 to 1, 000. The value of is not fixed, meaning that e-WayCOOL allowed students to key-in any integer number, later the number will be assigned to the first WK actor, followed by the second actor, third actor until n actor. Equation (1) is the sum of the computed numbers using addition operation, which is equal or less than 1, 000 ().

,
,
(0, 1000] (2)

Equation (2) is an example of total 3 actors which assigned numbers where number 100 for Sita Dewi, 50 for Ramayana, and 15 for Laksamana. 165 is the sum value for this addition operation.

Subtraction operation

Endure the same case; we unfix the value for (integer number,). is refer to the numbers of actor in a range of 0 to 1,000. The value of is always smaller than the value of, so that can be deduct by (See (3)). As an example of subtraction for visualization component is shown in (4).

(0, 1000]
(0, 1000] (3)

Equation (3) is a condition assigned to subtraction operation to evade any negative number, so that students could not see the sign of negative indeed determines the values is constantly positive numbers. An example of the total number for the subtraction operation turn into 35 as revealed in (4).

(0, 1000] (4)

Multiplication operation

Merely two numbers intricate in multiplication function, which is and as presented in (5)

[0, 1000], [1, 10]
(0, 10] and (0, 100] (5)
or
(0, 100] and (0, 100] (6)

Note that (5) and (6) is required to be in-between 0 to 100 for the combination and with the value for is in-between 0 to 10 and the value for is in between 0 to 100 or vice versa. So as to the total number for multiplication operation would become equal or less than () 1000. Notice that for and are always integer.

Division operation

Division operation wills fullfill the following definition;

Definition 1: (Susanna, 2011) Let be an integer and a positive integer. Then there are unique and with such that where.

In the 'division' operation function, three coefficients namely and would make its impacts. The operation is denoted by (7)

, , (7)
,
(0, 1000] (8)

Three coefficient must be followed for function (7) when value, so that (6). If, we may start (8) with the coefficient where by. Suppose we fix the values of, when. We can ask students to observe the corresponding changes of value, if getting bigger. Using the e-WayCOOL, the teacher can easily show students the conforming changes of value and here we use an example (7) with

In all 'division' cases, many hands-on exercises can be dispersed to students. With the help of e-WayCOOL, they may explore a lot more excercises with regards to division operation in the Mind Test module.

Arithmetic operation in Wayang Kulit characters

e-WayCOOL can be used in many situations when teaching a mathematics class. The four basic arithmetic operations are addition, subtraction, multiplication, and division. The numbers involve in this study are positive integer, where (0, 1000]. Adding and multiplying any two positive integers will increase the values. However subtracting and dividing two positive integers will decrease the value.

By displaying WK characters as in the concept of representation and arithmetic operation (AO) simultaneously in an e-WayCOOL interface, this fact gets visualized and efficiently described.

When teaching a basic arithmetic operation class, e-WayCOOL can be used to make the classroom instruction more effective. A typical example to use e-WayCOOL to illustrate the relation between 10 WK actors, four arithmetic operations, and the numbers is shown in Equation (9). This study considers the situation where the order of operations may vary and may not be followed (Dugopolski, 2006). In general, an expression concept has the form:

…, (9)
}
= Total of operations,

Where are ten WK actors with? The combination of all is allowed with any four operations which can be assigned as. The total value of is any possible integers amounting to one thousand. We do not fix the value of where students are allowed to assign any numbers in between 0 to 1, 000 ((0, 1000]). This expression concept (9) will suit any situation in the concept of representation in e-WayCOOL. Perhaps it is high time for students to conduct hands-on exercises with assist from teachers or parents by entering the values (0 to 1,000].

The representation concept in e-WayCOOL

E-WayCOOL is modeled based on the traditional WK, whereas mathematic contents are modeled based on the syllabus of Year One primary school. E-WayCOOL focused on L and T environment in which students should feel enthusiastic, energized, happy, and pleased (Te'eni, Carey, and Zhang, 2007). Such environment is hoped to cause changes in the users core affect as proven by the cognitive theory of multimedia learning (CToM) (Mayer, 2000). This theory emphasizes on two separate channels (auditory and visual) for processing information such as mathematics' contents in multimedia representation.

The details about the representation concepts engross in this phase is described in Figure-1. This model will focus on four mathematics operations for addition, subtraction, multiplication, and division operation, using four WK actors; Sita Dewi, Ramayana, Laksamana, and Hanuman Kera Putih. Each actor signifies ones, tens, hundreds, and thousands respectively. With each actor has its own numerical representation, the mathematics operations are realized through visualization, animation, audio cues, cinematography, and realism (Preece, Rogers, and Sharp, 2007).

An example for addition operation is shown in Figure-1. Two Sita Dewi added to three Ramayana equals 3,200. But, if this number subtracts nine Laksamana, the result is 3,200. Then minus 9, final result is 3,191 (See Figure-1). This approach is advantageous for students in requisites of trains on the use of variables, which will only be covered in form 1 syllabus of Malaysian school system.

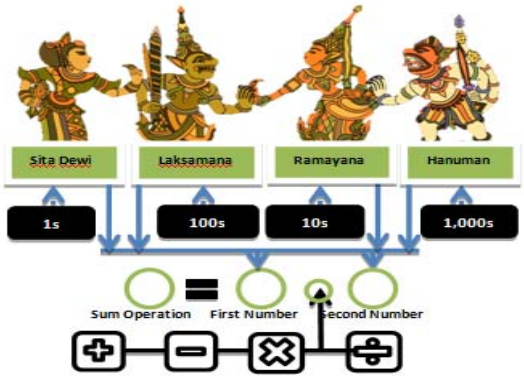

Figure-1: A proposed representation concepts in e-WayCOOL.

IxD INTERESTS IN e-WayCOOL

We are aware of the key aspects of e-WayCOOL design that influence student's emotional responses. The need for e-WayCOOL to convey positive emotions and avoid negative ones is critical to product success (Jasni, Zulikha, and Mohd-Amran, 2012). These aspects include positive, motivational, fun, engaging, motivational, creative, social, and persuasive influences, to name a few.

In e-WayCOOL, we used dynamic icon, i.e. when students click on icon numbers, it comes out with the spelling of the numbers as a voice over. The shrugs of WK actors as a 2D animation, and Tok Dalang (ToD)'s sounds help in communicating a state of mathematical operation. With this scenario, a sense of interactivity and feedback via confirmation dialog box are created. Interface aspects such as fonts, color palette, and graphical layouts can also influence an interface's perceived effectiveness. Hence, we focused on the four prominent principles of visualization i.e., proximity, alignment and balance, consistency, and contrast. Studies have shown that affective aspects can affect a user's perception of usability (Jasni, Zulikha, and Mohd-Amran, 2012).

IxD THEORY'S DIMENSIONS TO SUPPORT e-WayCOOL

Coiera (2003) states that the interaction design theory which is often abbreviated as IxD, has an interest in three dimensions, namely form, contents, and its main focus is on behavior (See Table-1). The IxD contents dimension is based on the mathematics level 1 KSSR syllabus, whereas the forms are fonts, color, and visual aspects (i.e., proximity, alignment and balance, consistency, and contrast). The behavior dimension in learning modules can be demarcated as navigation, control, dialog, feedback, pliant-pliancy, search, and tooltips (Jasni and Zulikha, 2014).

Table-1. The five IxD atributes expoused in e-WayCOOL.

No.	Dimension	Attribute	An example of attributes in e-WayCOOL learning modules
A1	Form	Words	List of Natural Numbers in between 0-1,000, Incorporated with Mathematical Operations (Add, Subtract, Multiply, Divide)
A2	Form	Visual Representation	WK Actors, Exit Icon, Navigation Buttons, Numbers
A3	Form	Physical Objects	Fruit (Mango) and Fish in the Story
A4	Behavior	Time	ToD's Voice Over in the Scenes, WK Actors' Gestures in 2D Animation
A5	Behavior	Behaviors	WK Music Control, Confirmation Dialog Box, Rollover to Get the Answers, Tooltips

The attributes of IxD were first introduced in the introduction of the book Designing Interactions by Moggridge (2007). He stated that there were four attributes for an interaction design language.

Figure-2. Spell number module interface.

A further fifth attribute was added by Kevin (2007). These five attributes in IxD theory dimensions are adopted in e-WayCOOL learning modules. These attributes are words, visual representation, physical objects, time, and behaviors (see Table-1). Table-1 describes some examples of attribute elements utilised in the e-WayCOOL. Figures 2, 3, and 4 are snapshots of spell number, subtraction and storytelling module interfaces respectively that depict the five IxD attributes delineated in Table-1. In all such cases, many hands-on exercises can be assigned to students. With the help of the five IxD attributes in e-WayCOOL, they can explore a lot more in the learning modules, and get more in-depth understanding of mathematical operation (add, subtract, multiply, divide).

Figure-3. Subtraction module interface.

Figure-4. Storytelling module interface.

0-10 Scale	No. of Respondents	Percentage %
10	3	10.0
9	2	06.7
8	10	33.3
7	9	30.0
6	3	10.0
5	1	03.3
4	2	06.7
3	0	00.0
2	0	00.0
1	0	00.0
0	0	00.0

Table-2. Respondent's interests towards adopting e-WayCOOL.

Preliminary evaluation on e-WayCOOL

The usability of the product is yet to be performed; however a random survey has taken place during the International Invention and Innovation Awards 2013 at Malaysia Technology Exhibitions (MTE 2013). The survey managed to compile results from 30 respondents. The purpose of the survey was to ascertain the participants' interest in e-WayCOOL. Table-2 shows the descriptive results of the survey where 80% of the respondents believe that the product catched their attention and that it is appealing enough as a L and T tool. Details are shown in Table-2 (Rank 7-10). The feedbacks were gathered during the 2-day e-WayCOOL. Majority of the score for the range of interest are between 7 to10. The score ranges from 0-3 (not interested) returns 0%.

CONCLUSIONS

Nothing is wrong with the traditional way of L and T mathematics but adding another method would mean we never stop trying to help the schoolchildren overcoming the difficulties in learning the subject. e-WayCOOL, as a courseware for L and T mathematics at primary school, is an additional tool that can be used in and outside the classroom. The project is driven by the challenges faced by the schoolchildren in understanding the representation concept in mathematics. e-WayCOOL proposes an alternative method to perform a meaningful representation to assist the learner in executing all four major mathematics operations, namely addition, subtraction, multiplication, and division. Ten WK actors are utilized in representing the contents and variables involved in the operations. We have an agenda of preserving this slowly vanishing cultural heritage when we decided to choose WK as a mean for the representation. The courseware communicates information via storytelling (voice and sound), animation and texts. The interface for the courseware is designed in a way that complies to the IxD theory. The courseware has been rated as 80% appealing by a random survey carried out during MTE 2013 exhibition.

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