Utilising Wayang Kulit for Deep-Learning in Mathematics

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***Abstract*—Previous studies proved that many students face difficulties in learning Mathematics which resulted in higher rate of failure. Similar studies also showed that by using the current L&T approaches, students' score on motivation was low. As such, this paper proposes an alternative approach in learning Mathematics, i.e. by utilising the shadow play (Wayang Kulit - WK) technique. This approach is the state of art and practice in terms of learning paradigm. We address the challenges that hamper the success of the Wayang Kulit technique for Deep-Learning (DeL) in Mathematics. Subsequently, we formulate strategies for modeling a Digital Wayang Kulit (DWK) application given a persona name of e-WayCOOL, in order to overcome challenges in L&T, specifically in DeL. The DWK model aims at helping primary school students learn Mathematics in a more engaging way by using the Rapid Application Development. Seven aspects of WK are combined to represent situation, behaviour, numbers, and mathematical operations which enable learning activities to take place. Control mechanism is also provided in the DWK model so that students can maneuver the characters in DWK.**

***Index Terms*—deep-learning, digital Wayang Kulit, Mathematics**

I. Introduction

LEARNING Mathematics using an interactive courseware is vital in today's education. It can be considered as a demanding subject with the aim of understanding the theories and visualising objects in the application of Mathematics operation (addition, subtraction, multiplication and division). In the midst of the highly developed multimedia technology, the difficulty can be occupied [1], [2], and the courseware come in a wide range and variety [3].

The main problem for students in learning Mathematics is requiring them to memorise the formulae and visualise the pictures purposely to understand the concept [4]. This results in a low perceived motivation level towards L&T Mathematics [1]. Hence, to improve the student's understanding towards Mathematics formulae in the courseware, the concept of Deep-Learning (DeL) was introduced. Using DeL, students can relate to the new idea, which is a WK component (national heritage) as a visualised object and linking them to already known concepts and principles of Mathematical operations. For better understanding, we integrate the WK components for students' retention towards long-term memory. At this juncture, DeL promotes understanding and application for life.

Conversely, the majority of the L&T courseware available in the Malaysian market only focuses on the subject matter without incorporating them with their values, such as the value of national heritage. Therefore, there is a need for education materials to provide students with practice and foster heritage knowledge. By simultaneously using the element of heritage as an alternative approach in learning a subject such as Mathematics, the learning process will be more engaging and entertaining. In a way, it promotes positive attitude towards learning Mathematics [5].

According to Nor *et al.* [6] Mathematics is an important subject for careers in the field of Science and Technology but incongruously, many students still have difficulties in learning Mathematics, as evidenced from the high failure rate. This claim is supported by Zaini *et al.* [1] and Ke and Grabowski [7] who studied students' motivation and performance towards learning Mathematics which was low.

In another research, students found it hard to visualise on how the concepts and theories of Mathematics are working in reality. In certain cases, they just memorise the theories and formulas [1]. Therefore, primary students who fail to master basic arithmetic and algebra will continue to have problems later on in related college subjects that require the use of this basic formula in their problem-solving activities. The most observed failure and substandard performance in Mathematics are due to insufficient L&T environment. Therefore, educational design of effective L&T environment should be considered a key factor in the preclusion and remediation of Mathematical learning difficulties among students.

Taking up the problem, we propose a conceptual model of DWK as a new approach for teaching Mathematics in Primary schools. This concept involves the use of WK as features of 'storytelling' and 'game' in the concept. The model combines the WK environment (actors, lights, shadows, scenes, sounds and music, and narrations) with the contents of mathematics subjects (Level 1). The aim is to help create an effective L&T environment that will enhance the learning of Mathematics and preserve the WK from dying-out.

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II. Learning and Teaching Environment in Malaysia

Currently, primary schools in Malaysia are impending to move from the traditional L&T to the student-centered learning (SCL) approach. By choosing the SCL approach we're inviting the students to be the active players in the L&T journey [8]. L&T activities through digital content will take full advantage of learning environment provided by modern information technology and a new communication mechanism and abundant resources to achieve a new learning style [9], [10], [11].

Nevertheless, L&T in Malaysia is still facing a problem in insufficient support digital content given no choice to teachers who remain to use simple media. Indeed they return to traditional ways, the methods used from earlier times, i.e. lecture based or teacher-centered learning. Conventional learning (traditional) is characterised by memorising than understanding, with priority on results rather than the process. In terms of L&T characteristics, traditional approach and DWK approach are compared accordingly to the following categories – materials, teaching method, approaches to learning, learning concepts, assessment, student's focus, and learning environment. Table 1 summarises the comparison.

TABLE I
Characteristics of Traditional L&T and DWK Approach

Category	Traditional	DWK Approach
Materials	a. textbook b. worksheet	Rich media a. audio and music b. visual c. 2D animation d. text and graphics
Teaching method	a. lecture b. question and answer	a. simulation b. interaction
Approaches to Learning	a. surface-learning	a. deep-learning
Learning concepts	a. 'chalk & talk' b. 'paper & pencil'	a. input device/mouse
Assessment	a. sequential test b. summative evaluation	a. randomize test b. repetitive c. formative evaluation
Student's focus	a. attention	a. attention b. retention
Learning environment	a. teacher-centered	a. student-centered

L&T Mathematics using "chalk & talk" is a 'one way' flow of information. Although such method remains valid, we can supplement it with digital contents that are more viable in a current technology era such as cinematography-based courseware. In this fashion, the courseware truly supports multi-sensory approach which is compulsory for better understanding content.

III. Wayang Kulit in Malaysia Society

WK is well-known performing arts. It is a symbol and heritage to the Malay society in Malaysia. There are four types WK in Malaysia, namely WK Melayu, WK Jawa, WK Gedek and WK Kelantan [12]. The most widely performed WK in Malaysia is the WK Kelantan (see Fig.1).

It was once fairly widespread, that the WK served not merely as an entertainment but more importantly it functioned as a vehicle for the transmission of norms, values and beliefs, and as an intermediary between the real and the nether worlds.Moral values are easier to absorb in the form of parables, which is why WK flourished in the villages. Ghouse clearly stated in his book "that traditional theatre (refers to WK) has been neglected and a few have succumbed to this neglect and died a natural death" [11]. One of the falloff factors of this traditional culture is the process of modernization. Cinemas, CDs, video tape recorders have conquered the space that was once used for WK. Furthermore, actions taken by a state in Malaysia that bans several traditional performances like performing arts of WK, *Menora*, and *Mak Yong*, has worsened the situation.

Fig. 1. Wayang Kulit Kelantan performance

It is clear that with the current situation and the level of support in Malaysia, WK Malaysia is unlikely to last long without some kind of strong official support [13]. It augurs well, for the local entertainment industry, that recently the Ministry of Arts and Culture has added Heritage to the functions of the Ministry [14]. Digitising WK is also an important step. It is needed taken to preserve this art from slowly vanishing. 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 [11].

IV. Wayang Kulit in Digital Age

In 2008, the first WK Kelantan animation entitled "Jala Emas Jala Perak" was produced by Art Media Production in Kota Bharu, Kelantan. However it only captured the narration recorded from the narrator (Tok Dalang-ToD) and the story which was originated from the Ramayana epic in WK Kelantan [15]. Some attempts have been done on the use of modern technology to capture the WK play. In 1996, a research project as 'Wayang Virtual' was established as an experimental version of the traditional WK from the technological perspectives, under Universiti Malaysia Sarawak. The virtual version of the traditional puppet or 'shadow' is combined together with a 3D animated figure and controlled by the ToD using a mouse on an SGI machine where the visuals were projected onto a white screen. This project had successfully combined the Arts and Multimedia technology. Hasnul Jamal from the Universiti Sains Malaysia had undertaken a production of multimedia experiment entitled "*Borrower the Light*". He incorporated a

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new adage of cyberpunk science fiction with Malay tradition WK Kelantan. This was followed by Tan, Zawawi, and Azam[15] describing a method of modelling a WK puppet using sophisticated computer techniques available in OpenGL in order to allow interactive play in real-time environment as well as producing realistic WK animation [16]. In 2011, a project on Technique Movement (3D animation) and Computer Graphic Imagery (CGI) used in WK Kelantan [14] was also reported.

Applying technology to WK theatre could be beneficial in some aspects, providing greater access to users especially youths viewing WK with modern technology. In doing so, we need a proper digital WK (DWK) model to assist the traditional WK to migrate to the digital form. With the intention of providing required guidelines and models, especially in the local culture environment, the concept of L&T approach in DWK is proposed.

V. How DWK Supports Teaching & Learning

To support the traditional T&L, DWK approach was introduced with five options namely cinematography, visualisation, 2D animation, audio-cues, and realism. Table 2 explained the representation of objects as contents to perform the Mathematical operations namely addition, subtraction, multiplication, and division.

An example for the operation of addition, two (2) Sita Dewi added to three (3) Ramayana equals 3,200. But, if this number subtracts nine (9) Laksamana, the result is 3,200, and then minus 9, the final result is 3,191. This approach is advantageous for students in the requisites of trains on the use of variables-which will only be covered in Form 1 syllabus of Malaysian school system. Additionally throughout these storytelling techniques, students gain more attention contributing to the DeL.

VI. E-waycool Development

We develop our own version of DWK, given a pesona name e-WayCOOL, as a new paradigm of learning Mathematics using DeL approach which is based on various pedagogical approaches and learning theories deemed suitable for primary school's students (Level 1), ages 7 to 9 years old. According to Piaget [17], children at the age of seven to eleven (7 to 11) can develop the capacity to think analytically. The design and development of e-WayCOOL was based on a well-researched conceptual framework (See Fig.2).

The content design and activities in e-WayCOOL are based on educational courseware development, Malay literature review on WK and ideas by expert groups from industries and education. E-wayCOOL is designed and developed as an edutainment that consists of 7 main components which are the DeL approach, holistic child development, instructional design and medium, IxD theory, and learning modules that incorporates with the established learning theories. In order to ensure that this courseware can eventually assist students to understand the contents, which is Mathematics Level 1, we integrated the environment of WK as a tool to make the deep learning process more engaging, effective, and expeditious and at the same time react as a tool to preserve WK for the future generations. The overall operational view of the e-wayCOOL model is explained below and illustrated in Fig. 2.

TABLE 2
Multimedia concepts embedded in DWK

Category	Characteristic	Represent in Concept
Cinematography	a. frame-by-frame motion action	Storytelling by ToD
Visualization	a. modeling puppet (graphics) b. stand out color c. manipulated puppets	10 prominent actors identified
2D Animation	a. replay animation b. fast movement c. shadow distortion d. limited movement	The movement of actors and props (left or right)
Audio-cues	a. programmed narration b. controlled sound c. can be edited d. added special effects e. synch. beforehand	Narrator, music, special effects
Realism	a. flat screen shadow with colors b. visual effects c. virtual environment	The movement of light and object on the screen, and camera views

A. Deep-Learning Approach

To involve students in mind and spirit, the WK scenes are introduced through the stories that are delivered as a DeL approach, which is known as the thematic literature-based approach. Here, the literature in context means ToD as the main narrator to communicate with students (users) on Traditional Malay oral narratives. Furthermore, through the stories in the scenes (Cinematography), students are exposed to recall their past experiences and develop their understanding, attention, and later retention.

The process of understanding becomes more effective when the contents (Mathematics in cinematography scenes) in line with the local culture and way of Malay life, helps the students to identify and relate themselves and their environment to the courseware. In unison the process of learning Mathematics becomes more fun, pleasurable, and appealing.

Malay Language is used as a whole language approach in e-WayCOOL purposefully to develop students' understanding during the learning process, with the intention that students can learn reading more effectively. The storytelling (narration by ToD) in the scenes is acquiescent to this approach. As mentioned by Bergeron [17], the whole language concept includes the use of real literature and writing in the context of meaningful, functional and cooperative experience in order to develop in students' motivation and interest in the process of learning.

B. Holistic Child Approach

In learning modules, Mathematical operations are the main important criteria to be tested by students while they have to think about problems and solutions using addition and subtraction, which refers to cognitive skills. Multisensory approach is adapted in these modules purposely to test the student's ability of receiving and responding. Students are able to utilise their multisensories

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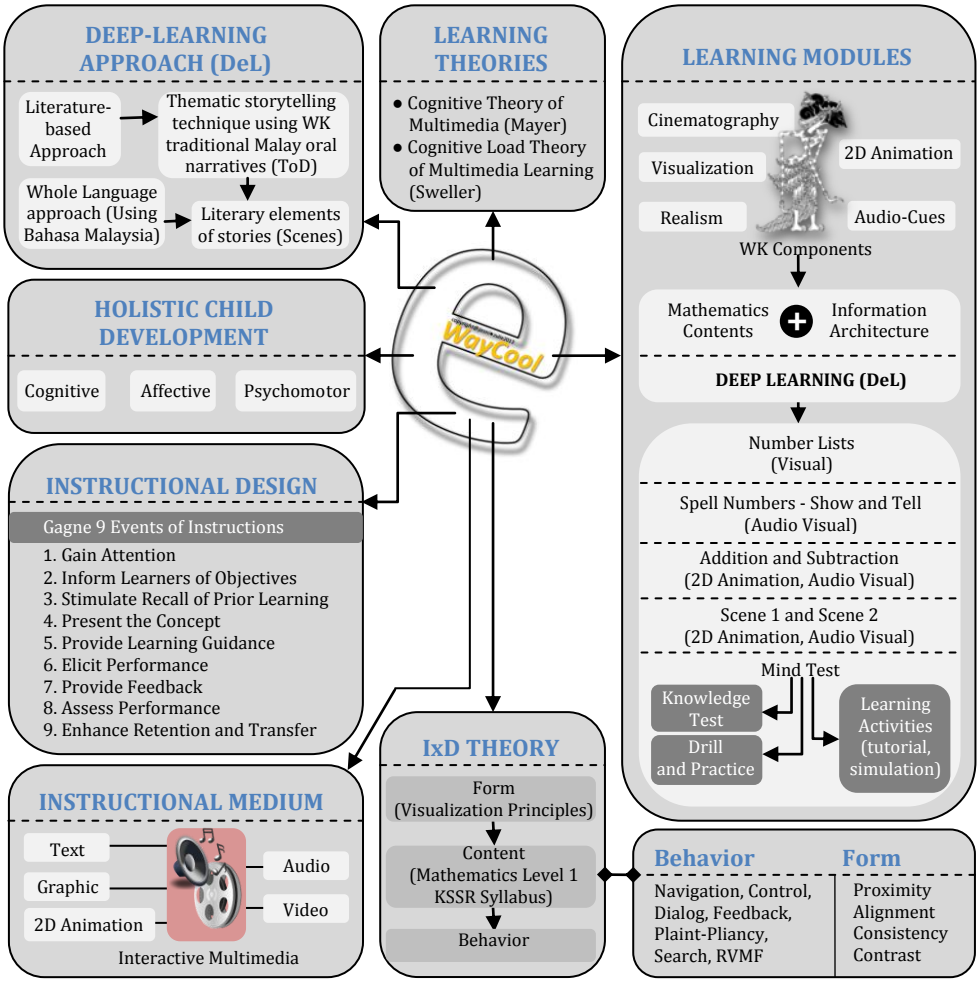

Fig. 2. Conceptual framework of e-WayCOOL

by manipulating the DWK's behavior easily. We add the components of WK with the purpose of creating intention, enjoyment, happiness and retention for the DeL process. These conditions are referred to affective students' activities and physical movement via interactivity with e-WayCOOL is referred to psychomotor.

C. *Instructional Design and Medium*

Nine events of instruction is the instructional design model put together by Robert Gagné [19]. We adapt nine events in e-WayCOOL which follows a systematic instructional design process that shares the behaviorist advance to DeL, with the focus on the outcomes or behaviors of instruction or training. These nine events are gaining attention, inform learners of objectives, stimulate recall of prior learning, present the content, provide learning guidance, elicit performance, provide feedback, assess performance, and enhance retention and transfer. These nine events are present in the multimedia components as a medium of student's interaction to support DeL. These components are the text, graphics, audio, video, and 2D animation. Multimedia is chosen as an instructional medium to convey the content of e-WayCOOL. The stories in WK cinematography scenes are presented in graphic, audio, and 2D animation. These multimedia components are combined together as an interactive edutainment with the ability to navigate through the material (Mathematics contents) to the students in very effective way. In this present study, multimedia play as a vehicle to project the intrinsic positive values of WK oral narratives for Mathematics operation.

D. *Learning Theories and IxD Theory*

Utilising the cognitive theory of multimedia learning (CToM) by Mayer [20], the cognitive load theory (CLToM) of multimedia learning (Sweller) [21], and the interaction design theory (IxD) adds values in terms of affective and psychology. As mentioned by Sweller [21] to augment the DeL process, e-WayCOOL embeds sounds and background music as these can directly affect the manner in which Mathematic contents are synthesized in working memory. The DWK as well utilises IxD theory in designing the layout and behavior of the interactions within e-WayCOOL (see Fig. 2).

E. *Learning Modules*

E-WayCOOL merges the idea of Mathematics' contents with the objects of WK in multimedia functionality to produce dynamic and flexible application to exercise thinking of mathematical activities while interaction, navigation, and exploring the scenes in WK with fun.

The details about the activities carried out in the study is described in Fig. 2. This module divided into five categories, which are cinematography, visualization, realism, 2D animation, and audio-cues. For examples, referring to the component of visualization, this model will focus on two mathematics operations for subtraction and adding operation

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(see Fig. 4), 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 mathematical operations are realized through visualization, animation, audio cues, cinematography, and realism. In cinematography category, we integrate the four core elements, which are the interactivity, stage, audio, and scenes (see Fig. 3) by using the ActionScript in Flash to program the application's behavior.

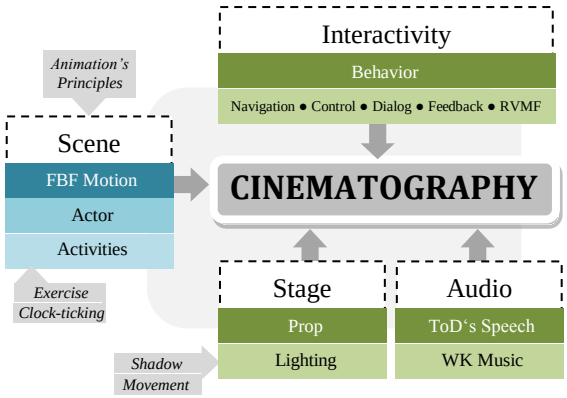

Fig. 3. The cinematography of e-WayCOOL Model

Number List, spell number, addition and subtraction, scenes, and mind test modules utilise the concept of multisensory approach where by students are able to learn (DeL process) Mathematics via exploring and experiencing the modules. Parenthetically, the application will facilitate student by providing a multisensory approach such as rich visual modeless feedback (RVMF), sound control, navigation, dialogue, and window feedback. Hence, learning based on multisensory approach, the process of DeL becomes more engaging and enjoyable.

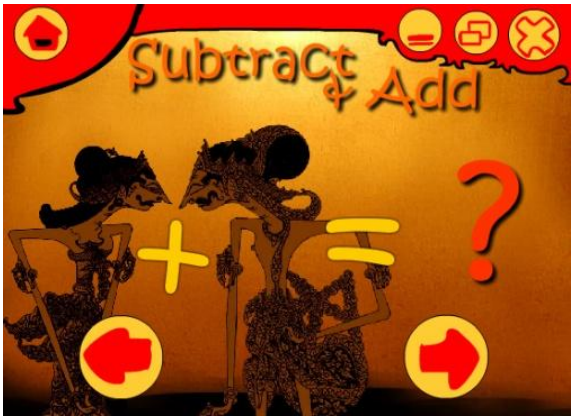

Fig. 4. Addition & Subtraction module

The mind test module is the final module into e-WayCOOL. Learning activities involved are knowledge test, tutorial, and simulation. The main objective of developing this module is to enrich the student's notion of Arithmetic. Overall, the learning modules adopt the holistic child development and DeL approach as a new paradigm that takes into account the Mathematics operation experience of students. It aims to strengthen the students' skill in Mathematics operation, and simultaneously promote and practice their cognitive skills throughout the activities.

VII. Result & Discussions

We propose an e-WayCOOL model with the intention to provide a solution to the existing problems of the L&T with poor results in Mathematics among primary school students Level 1 in Malaysia. The 7-components of the eWayCOOL model as shown in Figure 2 are seen as able to enhance the L&T process, supporting DeL.

In February, 2013, a random survey was conducted involving 30 respondents in Malaysia in order to ascertain their interests in the e-WayCOOL. The result shows that 80.0% of the respondents are very much interested in adopting e-WayCOOL. Details are shown in Table 3 (Rank 7-10). The feedbacks are gathered during the e-WayCOOL demo of 2-days duration. Majority of the score for the range of interest are between 7 to10. The score ranges from 0-3 (not interested) returns 0%.

TABLE 3
Respondent's Intention Towards Adopting E-waycool

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

VIII. Conclusion

E-WayCOOL explores a new paradigm of learning Mathematics using the cinematography approach, with purposes to construct and reconstruct students' thinking of Mathematics operation and related activities using the WK components. This paper has shown that an improvement on the traditional L&T is necessary. Hence, we initiate the e-WayCOOL as a tool for DeL approach and creating more fun and enjoyable stories for the primary school student of Level 1.In addition to the support of interaction design, e-WayCOOL reveals an interesting and exciting tool for L&T. The convergence between 2D digital (e-WayCOOL) and traditional WK is an alternative approach to maintain the precious heritage of the country. This approach might reinstate the interest of our younger generation in WK. Nevertheless, converting the traditional WK into e-WayCOOL needs a proper conceptual framework that can maintain the traditional values in WK, as well as preserving our national heritage. To do so, the DWK model was introduced. For designing the e-WayCOOL, we proposed a conceptual model of learning Mathematics using WK categories with seven components which have adopted the multisensory and DeL approaches. The results obtained have shown that 80.0% of the respondents are very much interested in adopting the e-WayCOOL. In the midst of the hope, e-WayCOOL with the concept of interaction design

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(IxD) would be able to address a new paradigm in learning and teaching Mathematics for future generation.

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