

EFFECTIVENESS OF STEM COURSEWARE BASED ON EDUGAME AND
ASSISTIVE APPROACH

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This dissertation is dedicated to my family for their endless support and encouragement.

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ABSTRACT

Implementing Science, Technology, Engineering and Mathematics (STEM) education in curriculum has become an ultimate target for many nations around the world. The implementation of STEM education also has been focused among Malaysian preschoolers. However, majority of preschoolers STEM education throughout the world still rely upon a traditional teaching format that reaches only a subset of student. Many preschoolers are lack of interest and engagement to learn STEM Education due to limited availability of interactive teaching method and tools. Research indicates that, there is limited high-quality assistive technology to drive effective practice for early preschool STEM education. On the other hand, playing games to acquire basic educational skills especially in preschools has been one of the most effective ways of learning. Although the discussion between these two technologies has been gaining strength in recent years, there are limited studies that cover the integrating features between them, especially for STEM education. The purpose of this study is to identify those elements of between the assistive technology and edugames and propose courseware design model for preschoolers STEM education. The study used a systematic literature review (SLR) as a method to identify the courseware component and element of assistive technology and edugames. Hence, the proposed courseware design model consists of four courseware components which are structural component, content composition component, learning approach and technology component. A prototype known as Bridge Master has been developed based on the proposed courseware model. Overall, the result showed a very high score obtained by the preschoolers has utilizing the courseware. This indicates, the Bridge Master courseware design model has been proven as effective for the preschoolers STEM education.

ABSTRAK

Melaksanakan pendidikan *Science, Technology, Engineering and Mathematics* (STEM) dalam kurikulum telah menjadi sasaran utama untuk banyak negara di seluruh dunia. Di Malaysia pelaksanaan pendidikan STEM ini juga telah ditumpukan di kalangan kanak-kanak prasekolah di Malaysia. Walau bagaimanapun, didapati, ramai kanak-kanak prasekolah kurang minat dan penglibatan untuk mempelajari pendidikan STEM ini kerana kaedah pembelajarandan alat pengajaran interaktif yang terhad. Kajian menunjukkan kekurangan assistive tehnology yang berkualiti untuk mempelajari pendidikan STEM di prasekolah. Selain itu bermain permainan (seperti, edugame) untuk memperoleh kemahiran asas pendidikan terutamanya di dalam prasekolah telah menjadi salah satu cara pembelajaran yang paling berkesan.. Tujuan utama kajian ini adalah untuk mengenal pasti ciri- ciri antara assistive technology dan edugames dan mengusulkan reka bentuk model perisian kursus. untuk pendidikna STEM prasekolah Kajian ini menggunakan Systematic Liturature Review (SLR) sebagai kaedah untuk mengenal pasti komponen kursus dan unsur-unsur assistive technology dan edugames. Melalui analisis perbandingan, empat komponen perisian kursus dikenal pasti. Oleh itu, model reka bentuk perisian kursus yang dicadangkan terdiri daripada empat komponen iaitu, teknologi, pendekatan pembelajaran, komponen struktur dan komposisi kandungan pembelajaran. Dengan meggunakan reka bentuk model ini, sebuah perisian prototaip bernama Bridge Master telah dibangunkan.Selapas itu, penilaian dilakukan untuk menguji keberkesanan perisian melalui ujian pra, ujian pasca, kebolegunaan, dan teknik pemerhatian. Secara keseluruhan, keputusan menunjukkan pelajar prasekolah tersebut mendapat markah yang tinggi serta memberikan kesan yang positif selepas menggunakan perisian prototaip

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LIST OF ABBREVIATIONS

STEM	Science, Technology, Engineering, and Mathematics
UTM	Universiti Teknologi Malaysia

CHAPTER 1

INTRODUCTION

1.1 Overview

This research provides a solution in an edugame courseware for preschooler's science, technology, engineering and mathematics (STEM) education by integrating edugame and assistive technology elements. This study also is conducted to identify an essential courseware for preschoolers STEM education. A courseware design model for preschoolers STEM education has been proposed with the integration of edugame and assistive technology element. Several other components also have been included in the design model and this will be discussed in other chapter especially in chapter two and four. As a validation of this concept, a prototype courseware has been developed that particularly can be used by preschoolers in learning the STEM education. The developed courseware prototype also has been tested with selected preschool to identify the objective of this study.

This chapter provides an overview of the study. It starts with research background of the study on STEM, and followed by problem statement. Next the research questions and objectives of the study are discussed to provide an insights about the studies main focus. The scope of the study and its significant are also discussed in this chapter. The organization of the thesis is briefly explained chapter by chapter. Finally, the chapter concludes with a description of the overall structure of the thesis.

1.1 Background of Study

In the past few years, firm escalation in funding and effort have been prepared to acquire Malaysian students to participate in fields that involve science, technology, engineering and mathematics (STEM). Concern for improving STEM education in many nations continues to grow as the demand for STEM careers and skills to meet economic challenges becomes more acute (Kelley & Knowles 2016). Malaysian government also has identified STEM education as one of the catalysts for transforming the country to a developed status by year 2020 (Ministry of Education Malaysia 2016). Through STEM education, technological development can be further upgraded to overcome the current challenges (Fadzil & Saat 2014).

Besides that, the implementation of STEM education also has been concentrated for Malaysian preschoolers. Preschoolers in Malaysia should be more focusing on STEM education to produce a scientific and progressive society who can retain creative and innovative skill. Implementing STEM education among preschoolers is visible due to the fact that children within age from 3 to 6 are able to learn the STEM context with a proper guidance (Adnan et al. 2016). Furthermore, preschoolers must be more exposed in engineering because this instruction can increase the children's curiosity and prepare them for more STEM related career in the future (Zucker et al. 2016).

However, encouraging the preschooler's interest in STEM education has become a huge challenge. Lack of connection with individual learners in a wide variety of way is one of the main threats to implement STEM education in preschools. Less attention on preschool STEM education can contribute to a lack of prerequisite STEM skills when the children advanced to primary school (Eck et al. 2015). Many preschools currently are still teaching STEM education in traditional method. All the barriers in implementing STEM education must be resolved since the elementary level to be highly significant achieves the nation's goals and objectives.

One of the strategies to encourage preschoolers to engage in STEM education is by utilizing interactive media tools and technology in their learning process. Integrating technological tools and materials enable to enhance the children's learning development, interactions, and collaboration. Other innovative tools such as multimedia can be utilized in the preschooler's education too (Agudo et al. 2015). According to Schroeder and Kirkorian (2016), it is very important to develop accessible, cost-effective interventions that prepare the preschoolers to be successful in STEM education.

Educational game approaches can be used in the classroom that promote high levels of preschooler's engagement, create a sense of community, and increase student retention in STEM education (Papanastasiou et al. 2017; Shemran et al. 2017). The edugame element in a learning courseware generally has a positive effect among preschoolers in term of performance and motivation during the learning process. According to Lester et al., (2014), edugames enable to provide a significant potential in preschoolers STEM education by engaging them to learn effectively compare to other traditional learning method. Besides that, assistive technology elements also can be integrated courseware to facilitate STEM education especially focusing in engineering among preschoolers (Berg et al. 2017). Assistive technology elements also can function as a powerful instrument for creativity and exploration without any barriers, as well as an engaging introduction to STEM education among the preschoolers (Buehler et al. 2014).

Therefore, this study provides a solution particularly about an edugame courseware for preschoolers STEM education by integrating the edugame and assistive technology elements. Thus, a courseware design model for preschoolers STEM education has been be proposed. Several other components also have been included in the courseware design model. To validate this concept, a prototype courseware has been developed that particularly can be used by preschoolers in learning the STEM education. The courseware prototype also has been evaluated among preschoolers to identify their learning efficiency in learning STEM education.

1.3 Motivation of the Study

Implementing STEM education in early education especially by integrating gamification and assistive technology elements is challenging. According to Amadio (2015), STEM education alone is not enough to enable innovation and necessity of organizing the learning experiences. This indicates that, to implement STEM education among preschoolers should be enabled with different learning method and teaching approaches. In this respect, there are few studies that have proven the most effective way to implement STEM education in preschoolers is by technology integration (Khaled & Vasalou 2014; Chiu et al. 2015; Yeh et al. 2016). Additionally, a few studies show that edugame (Lester et al. 2014; Kwak & Georgia 2015; Shemran et al. 2017) and assistive technology (Basham et al. 2010; Berg et al. 2017) enable preschoolers to learn STEM education in a more engaging and interactive way. For instance a study by Fisher et al. (2014) has proved implementing edugame in preschoolers education can provide a positive impact towards the preschoolers learning process. Besides that, another study by Basham, James D. (2013) has stated that by using assistive approach through implementing the universal design learning will enable the preschoolers to engage while learning the STEM education.

Edugame is one of the most suitable learning courseware that can be integrated in preschoolers STEM education (Lester et al. 2014). Edugame holds a great promise for preschoolers STEM education and need to be carefully designed to achieve the educational objectives and entertaining experience (Kwak & Georgia 2015). According to Shemran et al.(2017), integrating edugame in learning is a well-documented method to motivate and engage preschoolers with the course material in order to expand their learning outcomes. Besides that, assistive technology enables preschoolers to carry out daily learning tasks with more proficiency (Berg et al. 2017). Integrating assistive technology in preschoolers STEM education enables to design curriculum that can overcome the barriers inherited in most learning environments (Basham et al. 2010).

However, there is limited study that showing the integration between gamification and assistive technology especially for preschoolers STEM education. Therefore, this gap motivates the study to explore more on preschoolers STEM education by means propose a courseware design model by combining edugame and assistive technology elements. Later, a courseware prototype named as Bridge Master was developed based on the proposed courseware design model to validate the designed model for preschoolers STEM education.

Furthermore, a very limited study has been done about developing an edugame courseware for preschoolers in STEM education that especially focusing in the integration of assistive technology and edugames. As stated by Wu & Anderson (2015) edugame has the potential to be used as a route for large-scale STEM education in preschool. Thus, the goal of this study is to provide an alternative and effective way for educators , kindergarten institutions or any related organization to teach STEM education for preschool level Combining both assistive technologies and edugames in the courseware design could be a solution to assist and motivate the preschoolers to study STEM education.

1.4 Problem Statement

Implementing STEM education in preschooler's curriculum has become an ultimate target for many countries around the world. Nevertheless, majority of early STEM education throughout the world still rely upon a traditional teaching format that reaches only a subset of student (Repenning et al. 2015; Schroeder & Kirkorian 2016b). Many preschoolers are lack of interest and engagement to learn STEM Education due to limited availability of interactive teaching method and tools. This is because there is limited information for STEM education in preschool level and the main reason for the problem is most of the studies are focused more on higher education and less focus given to preschool levels. (Chiu et al, 2015). Besides that, there are very limited high-quality tools or technologies to drive effective practice for preschoolers STEM education (Ros et al. 2016).

Besides that, limited studies have been done about developing an edugame courseware for preschoolers in STEM education that especially focusing in the integration of assistive technology and edugames. Edugame also have the potential to be used as a route for large-scale STEM education in preschool (Wu & Anderson, 2015). Thus the goal of this study is to provide an alternative way for educators to teach STEM education for preschoolers an also identify an effective courseware for preschoolers. Therefore, the problem statement for this research is “How to propose courseware design model for preschoolers STEM education through assistive and edugames technologies.

1.5 Research Questions

Based on the problem statements described in section 1.3, three research questions are suggested as guidance throughout the research process. The research questions are as follows:

- i) What are the assistive technology and edugame elements that are suitable for preschoolers’ STEM education?
- ii) What are the suitable components to be implemented in the courseware design model for preschoolers’ STEM education?
- iii) How does each identified component be implemented in the study?

1.6 Research Objectives

The objectives of the study are as follows:

- i) To identify the elements of assistive technology and gamification that is suitable for preschoolers’ STEM education courseware.
- ii) To propose a design model of the courseware that contains a suitable component for preschoolers’ STEM education.
- iii) To develop a prototype courseware from the proposed design model for preschoolers STEM education and test its effectiveness.

1.7 Research Scopes

The study is limited to the following boundaries:

- i) The target users of this study focus on preschoolers. The edugame courseware generally targeted for preschool children where they need to be refined on STEM Education. Ayden innovation Islamic school which is located in Taman Universiti, Johor Bahru, is one of the main target audiences in this research.
- ii) Age of the preschoolers between 5 –6 years old. Since the target audience for this research is preschoolers and most of the standard preschooler's ages are within 5 – 6 years old.
- iii) The study will focus on preschoolers engineering and mathematics education.

The syllabus used for the engineering and mathematics education is based on Little Civil Engineer module from Ayden Islamic Innovation Preschool.

1.8 Significance of Research Study

The finding of this study should propose a courseware model in term of implementing STEM education for preschoolers. The proposed model will provide a guideline on how to develop a courseware that successfully help to integrate the STEM education with edugame and assistive approach. The guideline might help many parties such as educator, policy makers, and developer for effective and attractive learning process for future early STEM education. This study also enables to contribute and overcome the challenges in term of implementing STEM education among preschoolers because as mentioned previously one of the main challenge is very limited research in this topic. Besides that, this courseware also will practice STEM educational practice among preschooler's since their childhood. This will lead them to the development of interest towards information and knowledge of science, technology, engineering and mathematics since a very young age.

1.9 Organization of the Thesis

This section provides an overview of the overall thesis structure. Chapter one provides the background of the current research and highlights the objectives of this study. It then establishes the scope of this research and the research significance. This chapter also presented the overall organization of the current thesis.

Chapter two reviewed the relevant literature in respective research topic. This chapter presented the preliminary review where several gaps were identified in an effort to justify the significance of the study. Besides that, in the chapter two, the courseware component will be used to design the courseware model were identified. The assistive and edugame elements that will be included in the courseware have been stated in chapter 2. Other element such as multimedia also has been discussed in this chapter.

In chapter 3, the methodology adapted for this has been discussed. Chapter 3 will further elaborate on how data is collected organized and evaluated. This chapter will intimate how the researchers design to get the aim of the research by using principled approach of investigating the project subject.

In chapter 4, the proposed a model that combined assistive technology and edugame for preschoolers STEM Education will be justified. The chapter also reports the initial findings found viewing the literature by using a Systematic Literature Review (SLR) method adapted from Bandara et al., (2011). Furthermore result from interview session will be elaborated in this chapter.

The findings obtained from the courseware evaluation will be discussed in chapter 5. Three techniques were implied in this evaluation which is effectiveness, usability and observation. The result of this evaluation will be discussed in this chapter and the findings to prove the proposed model for the courseware is effective.

Finally, in chapter 6 the conclusion of this research will be discussed. The

research summary also will be explained in this chapter. There are also discussions as to whether the research objectives had achieved the goal or otherwise. The limitations and challenges of the research were also looked into in this chapter.

1.10 Summary

This chapter began with the overview of research topic and the structure of sections. Then, the research background and problem statement were discussed. The research questions and research objective also has been identified in this chapter. As stated all the research for this study will be conducted inside the research scope and objective of this study.

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