A Review of Learning Courseware for Preschoolers Science, Technology, Education and Mathematics (STEM) Education

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Abstract Implementing Science, Technology, Engineering and Mathematics (STEM) education in preschool’s curriculum has become an ultimate target for many countries. Early exposure to STEM education is critical to later academic achievement. Nevertheless, majority of STEM education 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. In this regards, learning courseware is deemed as the best option to provide a high-quality STEM education. However, there are limited studies reported on the existence of learning courseware for preschoolers STEM education. Therefore, this paper aims to identify the presence of STEM courseware for preschoolers and to propose the most effective courseware design for preschoolers STEM education. By using the four-stage method from Bandara’s Systematic Literature Review (SLR), it is found that multimedia application should be considered as the most effective component for developers while designing the learning courseware for preschoolers STEM Education.

Keywords: STEM education, learning courseware, preschool, systematic literature review

1. INTRODUCTION

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). Early childhood STEM education also is a part of appropriate practice which can be regard as a foundation of quality preschool experiences for all young children (Donegan Ritter, 2015). However, most of STEM programs that exist are focused on high schools and there is limited information on STEM at the preschool level (Chiu et al. 2015). Less attention on preschool STEM education can contributed to a lack of prerequisite STEM skills when the children advanced to primary school (Eck et al. 2015). This challenge can be overcome by implementing learning courseware in preschoolers STEM education because the learning courseware enable to increase student's motivation and engagement (Aronin & Floyd 2016). Therefore, different approach of learning should be used for preschoolers STEM education such as utilizing learning courseware.

Courseware is a term that combines the words “course” with “software” and courseware learning is known as the process of learning through a courseware (Lee 2012). Learning courseware such as video game can offer meaningful opportunities for preschoolers to engage with STEM education, learn through exploration, and practice newly acquired skills (Fashina, Lauricella, Beaudoin-Ryan, & Wartella, 2016). Besides that, by using an interactive multimedia, it in enable the learning process become more exciting to the children and the knowledge could be delivered and acknowledged easier (Muda 2006). Moreover, courseware also will practice STEM educational practice among preschooler’s since their childhood. This will lead them to the development of early interest towards information and knowledge of science, technology, engineering and mathematics.

Hence, this paper presents an investigation of the literature concerning learning courseware for preschoolers STEM education. It attempts to identify the existence of preschoolers STEM education courseware. This study also investigates the most effective courseware design for preschoolers STEM education. This study is significant to provide an imaginative and inventive approach to incorporate STEM education in preschool level. This paper is organized as follows. The following section, Section 2, presents the literature review on the topic of discussion. Section 3 discusses on the methodology used in the study. Then, the results and discussion from the
literature review analysis are explained in Section 4. Finally, Section 5 concludes the paper with potential exploration motivation for preschoolers STEM education learning courseware.

2. LITERATURE REVIEW

This section discusses related literature review.

2.1 Background of STEM Education

The term STEM education refers to teaching and learning in the fields of science, technology, engineering, and mathematics and it usually includes educational activities across all grade levels from pre-school to post-doctorate (Gonzalez & J.Kuenzi, 2012). Besides that, STEM education also is defined as a broad area encompassing many disciplines and epistemological practices or as using trans-disciplinary knowledge and skills in solving real-world problems (Hsu et al., 2017). An authentic STEM education is expected to build students’ conceptual knowledge of the inter-related nature of science and mathematics, in order to allow students to develop their understanding of engineering and technology (Hernandez et al., 2014). There are four fundamental fields in STEM education which is Science, Technology, Mathematics and Engineering.

Science is the first field that stands for acronym “S” in STEM education. Science education is significant to balance requirements of breadth and depth of knowledge about science to ensure young people and adult learners are both motivated to learn and equipped in scientific discussions and decisions as well as to facilitate further and deeper study (Hazelkorn et al., 2015). The science education plays a major role in providing opportunities for students to use and acquire higher-order thinking skills (Forawi, 2016). Young children’s have the intellectual capacity to learn science contrary to earlier ideas about child development (Pendergast & Cynthia, 2017).

Technology is the second field that stands for acronym “T” in STEM education. The word technology consists of two parts “Techno” means application, art or skill, and “Logy” means science and learning (Younes & Al-Zoubi, 2015). The most effective use of technology in an early childhood setting involves the application of tools and materials to enhance children’s learning and development, interactions, communication, and collaboration (Hernandez et al. 2015). Technology involvement capable to transform the creation of educational content for children, for example children can interact with touch screen and hearing an audio (Hirsh-Pasek et al., 2015). Integrating technology in preschooler’s education can provide students opportunities to think critically about technology and produce a technologically literate generation (Kelley & Knowles, 2016)

Engineering is the third field that stands for acronym "E" in STEM education. Engineering is defined as the application of the theory and principles of science and mathematics to research and develop economical solutions to technical programs (Sheppard et al., 2006). Engineering education must be regarded as a strategic foundational element, alongside technical research, in building innovation capacity (Kamp, 2014). Engineering education provide outstanding potential to increase conceptual understanding of STEM disciplines among preschoolers (National Research Council, 2010). Implementing engineering education in preschools opens up a number of opportunities for STEM learning to support the acquisition of knowledge and skills related to science and mathematics subjects (Balakrishnan et al., 2017).

Mathematics is the fourth field that stands for acronym "M" in STEM education. Mathematics is defined as a human activity involving the solution for problematic situations (Godino 1996). Mathematic education is important because it has a variety of uses more practical than rhetoric and it would be practically impossible for the common person to derive something more abstract than arithmetic without proper guidance (Tunstall 2017). Virtuous mathematics education can be endorsed when educators engage children in a variety of mathematically-related activities across different areas (Butler et al., 2014). Implementing early mathematics education via STEM education enables more growth in economic and STEM related workforce development (Weyer 2015).

2.2 Scenario of STEM Education

Nowadays, many countries (e.g., United States, South Korea, Turkey) have made a significant investments in STEM educational initiatives largely driven by concerns about potential shortfalls in STEM qualified professionals in the future (Kearney, 2015). Global educational initiatives and reforms have focused on increasing the number of students pursuing STEM subjects to ensure students are well-prepared, and suitably qualified to engage for STEM career (McDonald, 2016). Pursuing higher STEM education can be achieved by developing and increasing student interest in STEM domains right from their school years (Caglar et al., 2015). Implementing STEM education in preschool enable to contribute scientific leadership and economic growth (Fisher et al. 2014; Park et al., 2016; Subramanian & Clark, 2016). To facilitate STEM education in preschool, the necessary technological infrastructures are required to support the new curriculum and the children to enhance their learning with ICT (Grzybowski 2013; Aronin & Floyd 2016; Wang et al., 2017).

2.3 STEM Education in Preschool

Implementing STEM education in preschoolers is particularly beneficial because increasing children’s engagement at a very early ages can have cascading effects for their advancement in the future (Master et al., 2017). Besides that, integrated STEM education in preschool can provides opportunities for students to develop and explore technology through education (Samad & Osman, 2017). However, research show the adaptation of preschoolers in STEM education is still at minimal
because lack of learning courseware and technologies based on STEM education (Sheroff et al., 2017; Early Childhood STEM Working Group, 2017). Studies suggested courseware such as video game has the potential to be used as a route in preschoolers STEM education (Yurov et al., 2014; Wu & Anderson, 2015).

2.4 Early Childhood Education

Early childhood is the most rapid period of development in a human life (Thompson, 2001). During early childhood, the brain has the ability to adapt in response to a wide range of early experiences, which supports the rapid acquisition of language, cognitive skills, and socio-emotional competencies (Britto et al., 2017). Furthermore, young children are growing up in a new era which a broad range of modern technologies and their technological experiences differs substantially from the previous generation (Liu et al., 2014). Children who entering to kindergarten are ready and prepared with developed writing and speaking skills (Rankothge et al., 2012). This indicates that young children, especially preschoolers have the ability to learn education that integrated with technology in the young age. Besides that, ICT tools can help early childhood education to design and develop representations and interpret their thinking (Taylor, 2016).

2.5 ICT in Early Education

The impact on social life promoted by Information and Communication Technologies (ICT) represents a unique opportunity for educational development, as this facilitates and provides meaningful learning through technological resources (Nicolete et al., 2017). ICT tends to expand access to education and through ICT, learning can occur anytime and anywhere (Fu, 2013). ICT could provide students with more benefits and it is vital for schools and institutions to provide the best integrated education to their students (Luaran et al., 2016). ICT is well suited to supplement core classroom instruction by providing students with additional review and practice, especially in schools where the achievement gaps are wide and students are struggling to meet grade level requirements (Musti-Rao, 2017).

3. RESEARCH METHODOLOGY

The methodology used for this study is the Systematic Literature Review (SLR) adopted from Bandara et al. (2011). The use of this method is to address the existing courseware for preschoolers STEM education, and to identify the most effective component for designing it. Later, the collected results were summarized and reported. The subjects were provided with four phases of SLR method as shown in Figure 1. The next section will discuss the analysis of each phase.

3.1 Phase 1: Identification and Extraction of Articles

In this stage, reliable articles were chosen to conduct the research. The choice of articles was done in view of the inclusion and exclusion criteria. Inclusion criteria were done by utilizing keyword search such as "STEM education" and "courseware" and those articles published between 2009 and 2017. Another criterion of the inclusion is by selecting the articles written in English. In the interim, the exclusion criteria covers rejected repetitive articles, and those articles not written in English. After both inclusion and exclusion criteria have been contemplated, the articles were downloaded from online databases (i.e., Springer, IEEE, and ScienceDirect) as PDF documents. Mendeley program was used to deal with the references. An aggregate of 60 articles identified with the examinations were downloaded.

3.2 Phase 2: Preparing for the Analysis

To prepare for the analysis, 60 relevant articles were imported into NVivo software tool to conduct the analysis. The next step in this process is to set the first level coding node named "STEM education" and "courseware". Once the first node setting was done, all articles were read and relevant points were coded accordingly. After setting the first node, all the articles were perused and significant points were coded consequently.

3.3 Phase 3: Actual Coding

In the third phase, the main task is to create the actual code according to the related theme from the articles. A second level coding was created as the next step and a child node was created from the first coded text. The child node was named as “design component”. The entire design element for the existing preschoolers learning courseware for STEM education was analyzed from this code.

3.4 Phase 4: Report the Outcome

The main step in this phase is analyzing the coded article. The results demonstrate that the objective of this paper had been accomplished. The following section will discuss further about the findings.
4.0 RESULTS AND DISCUSSION

It is found that 8 studies had utilized learning courseware for preschoolers STEM education. Table 1 shows the summary of existing learning courseware for preschoolers STEM education.

Table 1: Existing Learning Courseware for Preschoolers STEM Education

<table>
<thead>
<tr>
<th>Courseware Name</th>
<th>Explanation</th>
<th>Authors</th>
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<tbody>
<tr>
<td>Agent Sheets</td>
<td>The National Science Foundation has initiates to use the Agents Sheets game in improving the elementary student’s self-efficiency in learning STEM education. This learning courseware has focuses more on technology in STEM education which is learning computer science in preschool. Agents Sheets courseware has included Learning for Use (LfU) as the design framework, multimedia elements and scaffolding as the learning approach. (Leonard et al., 2016)</td>
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<tr>
<td>Crystal Island: Uncharted Discovery</td>
<td>Lester et al. (2014), has introduced this STEM learning courseware for elementary pupil science education.Edugame and narrative centered learning environment design as the main component in this courseware. Multimedia elements also included in designing this courseware. (Lester et al., 2014)</td>
<td></td>
</tr>
<tr>
<td>CSNAP and Construct 2</td>
<td>Cooke (2016) as used the two gaming development software, Construct 2 and CSNAP as the learning courseware to implement STEM in preschoolers education. This learning courseware is mainly used to teach programming education for the students. The components utilize in this learning courseware are matematuning game based learning and discovery learning. (Cooke, 2016)</td>
<td></td>
</tr>
<tr>
<td>Hide &amp; Speak and Tone Bender</td>
<td>Doll et al. (2009) developed both of this courseware to provide an interactive web based platform STEM education games and lessons for preschool. The authors have used hybrid approach in designing these games. Multimedia is the main component used in this courseware. Both of this courseware focuses mainly in the physics education for children. (Doll et al., 2009)</td>
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Based on the findings, it can be concluded the existence of learning courseware for preschoolers STEM education. It shows that, these learning courseware have given a positive outcome for preschoolers learning process. Besides that, it was proven that multimedia application is the most used component in designing a STEM learning courseware.

Figure 2 shows the percentage of multimedia application used in all these existing learning courseware (75% of the existing STEM learning courseware is using multimedia applications). It demonstrates that six of eight studies implemented multimedia component for designing courseware. They were Astra Eagle, Crystal Island: Uncharted Discovery, Hide Seek, Tone Bender, Measure the Animal, Turtle Art and You Make Me Sick.

Multimedia is an exciting combination of computer hardware and software that allows you to integrate text, video, animation, audio and graphics to develop effective presentations on an affordable desktop computer (Azran et al. 2017). Multimedia can be utilized in courseware as one of the teaching and learning aids that
can help to diversify the technology used in education (Aziz et al. 2014; Yusrina et al. 2014). The use of multimedia technology for the creation of children's learning situation, effectively stimulate the children's interest in learning, and fully mobilize their senses, to develop children's thinking, cultivate their innovative spirit (Nie 2017).

![Courseware Design](image)

**Figure 2:** Most employed element for STEM courseware design.

Besides that, Figure 3 shows the finding of the number of courseware that has been developed from 2009 to 2017 with total numbers of eight. 2016 is the year that highest number of STEM learning courseware has been developed which is three courseware, followed by the year 2015 which is two courseware. For the year 2009, 2013 and 2014, only one courseware was developed. However, in year 2010, 2011 and 2012, no learning courseware for preschoolers STEM education has been developed. This indicates that, for the past 5 years the number of STEM learning courseware are keep increasing compare to the previous decade. Recent improvement in the development and implementation of STEM related courseware has proven that more focus has been shown by many authors and institution to implement STEM education among preschoolers. Furthermore, all the existing learning courseware has proved the importance of multimedia for STEM education.

![Number of Courseware Developed by Year](image)

**Figure 3:** Number of Courseware Developed by Year (2009-2016)

5. CONCLUSION AND FUTURE WORKS

This study has successfully investigated existing learning courseware for preschoolers STEM education and the most effective approach for designing the courseware. SLR method used assisted this study in identifying the existing learning courseware for preschoolers STEM education. From the findings, the learning courseware was identified that enable to help the preschoolers to learn STEM education in more interactive method. It also shows that the preschoolers have an easier learning process in utilizing the courseware compared to traditional teaching method by using a textbook. This strategy will provide a creative and innovative way to integrate STEM education in elementary level. Besides that, it is also proven that including multimedia application in learning courseware is necessary to motivate and engage the preschoolers.

However, the current existing learning courseware for preschoolers STEM education are viewed as deficient in light of the fact that the children require more assistive and inspiration that could connect with them to adjust the learning procedure. Thus, in implementing STEM education in preschooiler’s education more courseware must be developed to motivate and provide engagement for the students. Consequently, for future works, this reviewed study can be utilized as a direction or reference by different researchers in conducting the comparable studies especially for those in developing courseware for preschoolers STEM education.

6. REFERENCE


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