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The Development and Evaluation of Augmented Reality Learning Application in Geometry Topic

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Abstract
The application of technology should be applied by teachers and pupils to be prepared with knowledge and skills that can provide positive impact in teaching and learning. Hence, the Malaysia Education Blueprint 2013-2025 was developed by the Ministry of Education which emphasizes on the use of technology and innovation that can improve the achievement of students. Pupils in primary school face difficulties in basic concepts, reasoning and problem solving in geometry. Based on the global benchmarking of Trends in International Mathematics and Science Study (TIMSS) test report in 2019, the average score of mathematics achievement for Malaysian students is at a low level compared to other Southeast Asian countries like Singapore which are at the highest-level score in the world. Moreover, geometry domains also reported as low levels from 2007 to 2019. Most of teachers use drawings on whiteboards, static images in books and verbal explaining to describe three-dimensional shapes to pupils. In this regard, the innovation of learning application utilizing Augmented Reality technology was developed for pupils. This study used ADDIE's instructional design model as a framework to develop the application. This study used three experts' interviews to confirm the need for developing this application and quasi experimental to evaluate the effectiveness of the application to 30 grade 2 pupils. This study is hoped that the AR technology applied can improve the effectiveness of learning, increase motivation and creative thinking skills of students in solving problems especially in geometry topic.
Keywords: Geometry, ADDIE, Augmented Reality

Introduction

Globally, technology has advanced at a breakneck pace, influencing the transformation of education in Malaysia. Therefore, the Malaysia Education Blueprint (2013-2025) focuses on the seventh shift, leveraging on education technology to improve the quality of learning in Malaysia. In fact, the primary school mathematics education curriculum also focuses on aspects of creativity and innovation, along with information technology and communication

elements, so that students become creative, teaching and learning become more engaging, and improving students' understanding (KPM, 2017). In addition, the application of technology in teaching and learning can create a conducive learning environment, fun, encourage high level learning as well as master the basic digital skills among students starting from the low level (Outhwaite et al., 2017).

In line with the development of technology, mathematics education has also received its effects. Primary school mathematics education is aimed pupils to master the basic mathematics skills and concepts of mathematics. Pupils need to master's in mathematics since primary level to prevent difficulties in secondary school onwards. Content, pedagogy, and teaching design integrated with technology should be planned by teachers to produce fun teaching and learning in the classroom (Law & Rosli, 2020). However, previous studies have found that low visual skills are the major factor influencing the understanding of geometry concepts for grade 2 students especially in understanding the basic concepts of 3D shape characteristics (Berna, 2014; Gunčaga & Žilková, 2019; Ibili et al., 2019).

One of the technologies that can be applied in teaching and learning geometry is Augmented Reality (AR). AR technology allows users to interact with virtual objects that are integrated into the physical world and appear in the same space and in real time (Azuma, 1997). AR technology is also classified as a technology combined with multimedia elements such as three-dimensional animation (3D), image, graphic, audio and video via camera available on devices such as tablets, iPad, smartphones, laptops, and computers (Li et al., 2019). Various past studies in AR were conducted by researchers on the advantages in education (Sirakaya & Sikaraya, 2020). Among the benefits in AR is that teaching, and learning become more easier in understanding abstract concepts (Akçayir et al., 2016). Next, AR can also attract students' attention to teacher teaching (Bressler & Bodzin, 2013) and increase motivation (Chang & Hwang, 2018; Ibanez et al., 2015). Moreover, learning through AR technology can attract and delight pupils (Gün & Atasoy, 2017) as well as improve spatial visualization capabilities (Lin et al., 2015).

Augmented Reality (AR)

Augmented Reality is a technology that combines virtual information with the real world (Chen et al., 2019). In this context, 3-D virtual objects which is the geometry shapes combined with a 3-D real environment. Virtual and real geometry shapes appear together in a real time system in a way that the user sees the real world and the virtual objects superimposed with the real objects. The user's perception of the real world is enhanced, and the user interacts in a more natural way. The virtual objects can be used to display additional information about the real world that are not directly perceived. Milgram and Kishino (1994) introduced the concept of a Virtuality Continuum classifying the different ways that virtual and real objects can be realized. In this taxonomy scheme, Augmented Reality is closer to the real world. Azuma (1997) defines AR systems as those that have three characteristics which are combining real and virtual, interactive in real time and registered in 3D. In general, AR applications fall in two categories: (i) Marker-based AR and (ii) Marker less-based AR.

Marker-based AR requires a specific marker or label to register the position of a 3D virtual object to be displayed in a real-world environment. Hardware such as mobile device cameras and markers or labels in the form of QR codes are commonly used in marker-based AR applications. Image recognition is based on where the marker is placed on the screen display. Next, it will produce a matching 3D version of the image that can be rotated. Thus, the user can view the object in more detail and various angles. Next, marker less-based AR is a new

advancement in AR technology that using sensors in mobile devices, global positioning systems (GPS) and any part of the real environment to detect real world environments, such as location and intersection points that allow users to place virtual objects into real context without having to read images (Yih & Chun, 2019).

Development of the Augmented Reality Application

The ADDIE framework is used in the development of the AR learning application (Rosset, 1987). This framework is systematic and organized, with few phases in the development of applications, systems, or software (Taufiq & Aziz, 2018). Figure 1 represents the framework to design the learning application which consists of analysis, design, development, implementation, and evaluation.

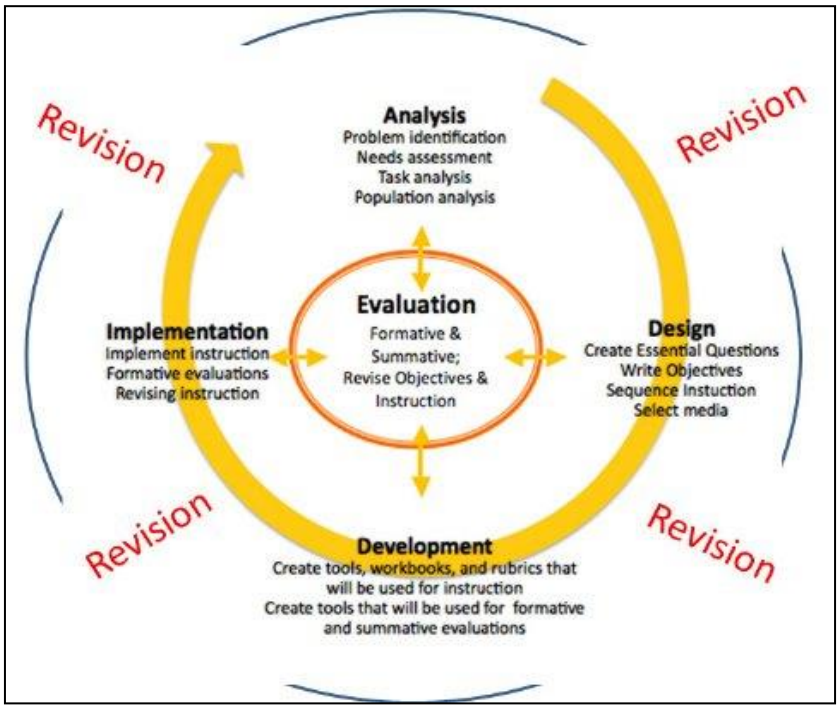

Figure 1: ADDIE Framework (Rossett, 1987)

Analysis

In identifying the problems faced by students in Shape and Space topics in mathematics and the need to develop this learning application, semi-structured interviews were conducted against three specialist teachers who taught mathematics education more than five years (Akbari & Yazdanmehr, 2014; Berliner, 2004).

Design

The design is obtained from findings in the first phase of the analysis and identify the objectives that need to be achieved. The elements considered in this phase are such as teaching and learning methods, learning theory, learning objectives, learning activities, teaching and learning plans, teaching strategies, and media selection (Larson & Lockee, 2014). In addition, it is important for researchers to create storyboard related to technical and visual design as well as multimedia elements such as text, images, animation, and video through storyboards. The designed storyboard will illustrate the overall display of the application.

Figure 2 depicts a flowchart of the processes that will occur in the AR learning application's content structure.

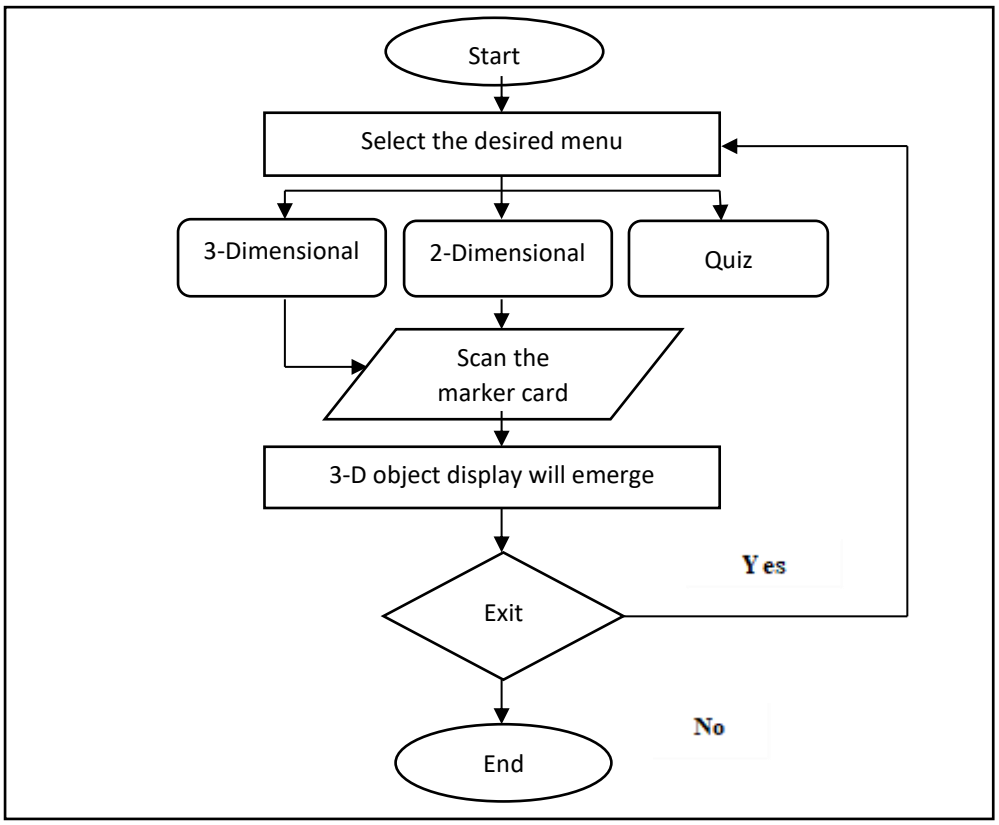

Figure 2: The flowchart of the AR Learning Application

Development

The development phase refers to the development of application prototypes. Multimedia elements such as the use of appropriate text and colour, the use of audio, image, animation, video, and graphics to ensure that the applications developed will have impact on student learning (Mahzan & Othman, 2019). This study will use mobile and marker-based AR in learning process. Besides that, the alpha test of expert evaluation was conducted to determine the robustness of the application user interfaces and functionalities (Alessi & Trollip, 2001). The purpose of alpha testing is to discover errors in the application before providing it to the end users. Meanwhile, a beta test entails evaluating the whole learning application produced and testing it on students to get feedback (Maccormack, 2001).

Implementation

Once the AR learning application and geometry test developed have been authenticated by experts and are ready to be utilized, it will be implemented to grade 2 students. It is a need to test the learning application and geometry test developed that can be used in the context of actual sample. The pilot study was given to 30 students to gain the reliability of the test.

Evaluation

The developed AR learning application would be examined for testing and evaluate the effectiveness on students' achievement for geometry topic based on the pretest and posttest. Therefore, the non-equivalent groups pretest-posttest design for quasi-experimental

research design will used in this study. The data acquired from this evaluation is utilized to make decisions either the learning application developed is useful or ineffective via a quasi-experimental research at the end of the study. Table 2 represents the quasi-experimental design which will conducted in this study.

Table 2: Non-Equivalent Groups Pretest-Posttest Design

Group	Pretest	Teaching Approach	Posttest
Treatment	O_1	X_1	O_2
Control	O_3	X_2	O_4
O_1, O_3	Geometry Topic Pretest		
O_2, O_4	Geometry Topic Posttest		
X_1	AR Application Teaching Approach		
X_2	Conventional Teaching Approach		

Conclusion

Research in the utilization of AR technology for the purpose of promoting primary school is still new. The development of AR application is targeted to the prospective primary school pupils to attract and gain the understanding on geometry topic. Since most of the pupils are using smartphone nowadays, the idea of developing the application coincides with the needs of pupils. It is hoped that the findings of this study will encourage more pupils to use the AR applications in understanding about geometry topic especially in 2D and 3D shapes. At the same time, it will help the teachers and Ministry of Education to introduce a new learning strategy using AR technology which is more creative, innovative, informative, usable, trending and up to date. Plus, this application will help pupils to achieve a good achievement in mathematics education and give a lot of benefits of using mobile in learning mathematics.

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