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Augmented reality: effect on conceptual change of scientific

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ABSTRACT

In recent years, Augmented Reality (AR) has received increasing emphasis and researchers gradually promote it Over the worlds. With the unique abilities to generate virtual objects over the real-world environment, it can enhance user perception. Although AR recognised for their enormous positive impacts, there are still a ton of matters waiting to be discovered. Research studies on AR toward conceptual change, specifically in scientific concept, are particularly limited. Therefore, this research aims to investigate the effect of integrating AR on conceptual change in scientific concepts. Thirty-four primary school students participated in the study. A pre-test and post-test were used to assess participants' understanding of the scientific concepts before and after learning through AR. The findings demonstrated that 82% among them had misconceptions about the scientific concepts before learning through AR. However, most of them (around 88%) able to correct their misconceptions and shifted to have a scientific conceptual understanding after learning through AR. These findings indicate that AR was effective to be integrated into education to facilitate conceptual change.

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1. INTRODUCTION

Over the last two decades, augmented reality (AR) has been receiving attention. AR is an innovative technology that can supplement computer-generated sensory inputs to a real-world environment. AR is an interaction between human and machine tools for computer supplemented information to the real-world environment [1]. These virtual models generated by the computer seem to coexist in a real-world with instantaneous interaction; thus, it can increase people awareness of the model that closed to genuineness. Generally, AR is a technology based on 3 Dimensional (3D) that compromising the three components: a mechanism to track data about actual objects [2].

The AR-based technologies have been recommended for their massive potential to facilitate individuals to build better understanding [3]. By overlaying the virtual information over real-life environments, the mixture display of the digital augmentations offers scaffolding for viewers to experience and perceive computer-generated virtual elements as part of their present world [3]. In so doing, the augmentations assist viewers in exploring aspects of the world in more concrete ways that might unachievable with the use of other technologies.

With this unique ability, AR is one of the technologies that has emerged and used in a different field, especially education. A lot of researchers study AR for schooling to boost up student performance

[4, 5]. The main factor of AR acceptance for education, it's because of the accessibility and economical with mobile phone.

AR has been applying in the education field to create unique educational learning. According to the 2016 Horizon Reports, AR with its information over 3D spaces can create a new experience and recommend that AR technologies should apply to bring new opportunities for teaching, learning technique, research and creative inquiry [6]. AR, with its features attractive 3D animation with sound and haptic sensation, might attract educational practitioners either student or teacher. Its can increase the interactivity between student and the learning module as well as their teacher [7]. As regards to the advantages of AR, the digital augmentation is supplemented into a real scene to give enhancements to the computer simulation and promote student's realistic experience.

Despite this, the AR issues of conceptual change, especially in science education with the use of AR technology are rarely discussed [8]. Markerless and location-based AR widely used for augmenting the navigation as well as instruction for people [9-12]. Previous studies on science education have revealed that students frequently hold robust misconceptions that are contrary to actual scientific concepts. These pretentious ideas labelled as alternative ideas or misconceptions in science education [13]. According to [14] the alternative frameworks that students possess are opinions and perceptions that differ from the theories of scientists.

A study conducted over the past 40 years has proven that students face misconceptions issues in several scientific concepts. Among the main topics often associated with an alternative framework in science is the astronomy concept. To date, there are many studies conducted in various countries that focus on astronomical concepts. The findings of most studies show that not only children [15] but also adult learners [16] also face misconception problems as well as difficulties in explaining the basic natural phenomena. In traditional method of teaching, educators mostly will devote their period performing teaching [17], and the learning material based on static materials [18]. Therefore, learners hardly get opportunities to gain more understanding due to static materials unable to show any information in a dynamic way where the contents required showing that motion and continuous movement to represent the concept.

With the advancements in technologies, technology-based education has become an important trend and dramatically affected the teaching and learning process [19]. Through one new visualisation technology that has emerged, AR may have the potential to situate students in conceptual knowledge development. The learning capability of AR mostly applied in higher education settings. Thus, research studies on primary school education are particularly limited [20]. Therefore, this research attempts to explore the potential impact of AR for schoolchildren's conceptual change of scientific concepts especially in astronomical phenomena and concepts.

2. RESEARCH METHOD

To observe the effectiveness of AR on theoretical change, the experimentation performed on primary school science grade to evaluate the scholars' conceptual change before and after the instruction. The selected subject unit was "Investigating the Earth and the Universe" unit of a primary school science course.

2.1. Research design

This research carries out two models of experiments: pre-assessment and post-assessment. This study examined how student understands was change from misconception to the scientific concept after learning through AR. This study comprises of three main phases: i) pre-assessment, ii) AR initialisation and iii) post-assessment.

2.2. Participant

Convenience sampling method was used in this study because of the selection based on the accessible school. The teachers select students who participated in the survey. Around 34 students (32% male, 68% female) from one of the fifth-grade primary school in Malaysia involved in this study. The justification for selected students of this grade due to them has some of the concepts of astronomy.

2.3. Instruments

The research instruments of this study included the pre-test and post-test for measuring the student's concepts before and after the instruction using AR. Pre-assessment and post-assessment: With the resolution of gathering a thorough information about the students' conceptual change of astronomy, the pre-test and post-test were constructed to measure students' understandings of three targeted astronomy concepts: A "travel of the earth, moon and sun", "daylight and nighttime event", and "moon stages". The pre-assessment and post-assessment were the same, but in a different order with multiple-choice items, drawing and labelling

and structured questions. The questions in both tests were referred to the textbooks and teaching materials and validated by the two experts with science subject.

The AR book developed to help schoolchildren learn and overtake misconceptions about science concepts. The 3D virtual objects were prepared using an Autodesk Maya, and the AR platform was developed using Unity 3D. This AR educational tool enabled the webcam/camera to recognise pages in the book and turn them into 3D presentations. Users can read the book, look at the pictures and turn pages without any external technology. The only requirement to run this system was basic equipment such as a laptop/desktop, AR markers and a webcam/camera to view and render all multimedia virtual objects such as 3D virtual objects. The virtual objects can be manipulated using real physical AR markers by just using a bare hand. This natural interaction is a unique way that AR can offer to bridge the real and virtual worlds. Each page of the developed AR application consisted of notes, pictures and AR marker that represent the virtual objects. There are also the instructions listed below the notes part that will guide the user which marker to use. Once schoolchildren initiate the system, they can start searching and using markers to interact with virtual objects. The camera will track the pattern on the book and starting to display the 3D model of earth, sun and moon. This sensation fascinates student to do more interaction with the AR system as shown in Figure 1.

Figure 1. An educational AR book

2.4. Research procedure

Figure 2 illustrates the experimental procedures of this study. While Figure 3 illustrates the settings of this study in the school laboratory equipped with personal computers and web cameras. Initially, 34 participants sat for the pre-test before the AR treatment. This phase was to determine their conceptions of the content before given the AR treatment. During the next phase, participants have a brief training on managing and use AR-System to prevent inappropriate usage and misunderstanding. Firstly, the teacher guided participants by posing a problem on the related topic. Based on the problem given, the participants were required to conduct explorations on the topic by referring to AR application. By using the provided AR application, they have the freedom to employ the concepts where they required deliberating, reflecting and making inference on the problems given in the learning activity. In the first topic, the participants investigate the concept of the travel of the Earth, the Sun and the Moon. Five AR markers were prepared in this topic to represent simulations of computer-generated models. Afterwards, the students will learn on the second topic which was about the occurrence of the day and night. This topic involved two AR markers to represent the Sun and the Earth. The participants will explore how the day and night happened by using the AR markers provided. Phases of moon were the third topic for this research. The participants learned about the eight most important periods happening to the moon. An AR marker will represent the moon while there are eight positions of areas presented to demonstrate every stage of the moon. Once the training with AR completed, each participant was required to sit for post-test to acquire the conceptions after the AR treatment given.

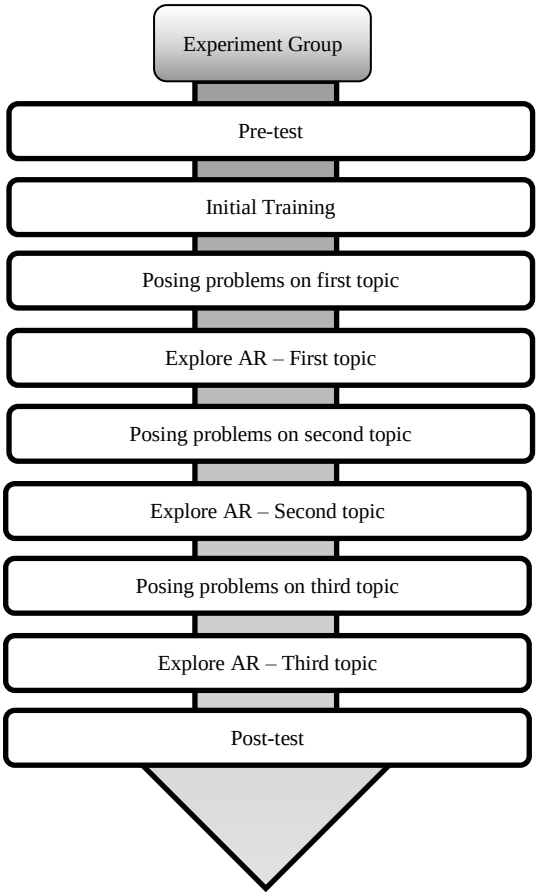


Figure 2. The research procedures

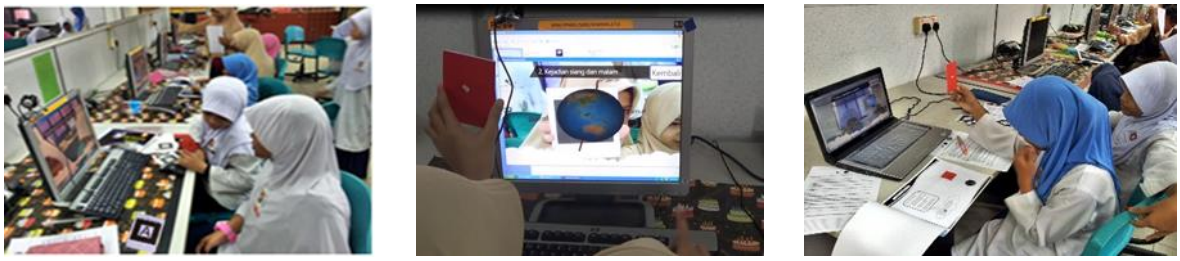


Figure 3. Student interaction with AR application

3. RESULTS AND DISCUSSION

The conceptions of the participants were assessed before and after the AR treatment by analysing their responses to the pre-test and post-test. The analysis used to classify the data based on the categorisation of the responses that classification into the scientific concepts (correct explanation-label as **"a"**) and misconception (incorrect explanation-label as **"b"**).

Table 1 shows the concepts understand by the participants on the travel of the earth, the moon and the sun before and after interacting with the AR system. First, for the concept of rotation of the earth on its axis. Looking into the answers (pre-test) before the AR treatment showed that only six students (18%) were able to provide accurate answers while the majority (82%) failed to provide an accurate answer. After the AR treatment, the findings demonstrated that all the students manage to provide an accurate answer to the scientific concept for this concept. Secondly, the concept of the earth rotates around the sun. The answer shown by the student before the AR treatment showed that only three students gave the correct answer while the majority (91%) gave the wrong answer, explained the event according to misconceptions that the earth

rotates around the Moon. After a learning session with AR, majority of participants (85%) were able to provide the correct answers. Out of 31 students who gave incorrect answers before treatment, only 2 participants remained with this idea even after AR treatment session took place. Besides, the findings also show that no student was able to provide the correct answer for the Moon's rotating on its axis and circulating around the Earth. But after the treatment, majority of the participants managed to provide an accurate answer.

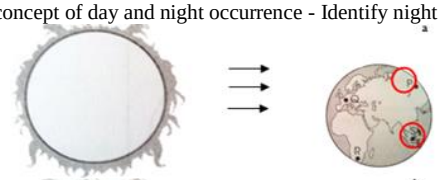
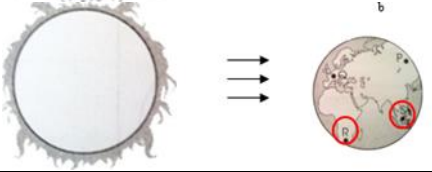
Table 1. Student's conception of the lunar phase and its rotation

Concepts	Pre-assesments *f* (%)	Post-assessment *f* (%)
a) State the rotation of the earth on its axis		
- The Earth rotates on its axis from west to east [a]	6 (18)	34 (100)
- The Earth rotates on its axis from east to west [b]	28 (82)	0 (0)
b) State the Earth rotates on its axis and at the same time revolving around the Sun		
- While rotating on its axis, the Earth also revolves around the Sun [a]	3 (9)	29 (85)
- The Earth revolving around the Moon[b]	31 (91)	5 (15)
c) State the Moon rotates on its axis and at the same time revolving around the Earth		
- The moon takes 28 days to complete revolution around the Earth [a]	0 (0)	32 (94)
- The moon takes 365 days to complete circulation around the Earth [b]	33 (97)	2 (6)
- No response	1 (3)	0 (0)

a. Scientific Concept b. Misconceptions

Table 2 shows the conceptions that participants understand the concept of day and night occurrence before and after learning session using AR. A look into participants answers on how the day and night occur before using AR shows that majority of the students (56%) were able to provide accurate answers. Among the misconceptions answers with the highest percentage (26%) was "the moon rotates on its axis," followed by "the moon revolves around the earth" (12%) and "the change in climate and weather" (6%).

Table 2. Student's conception about the day and night occurrence

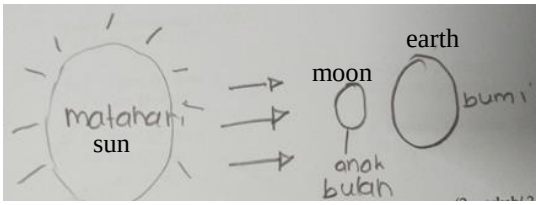
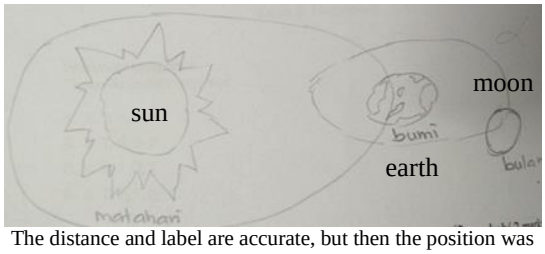
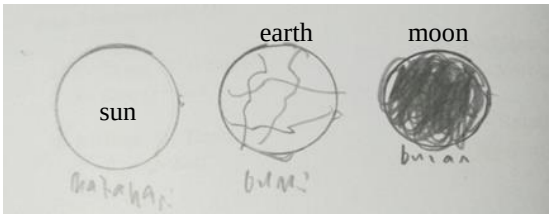
Concepts	Pre-assesments *f* (%)	Post-assessment *f* (%)
a) The day and night occurrences on Earth are caused by...		
- The rotation of the earth on its axis [a]	19 (56)	34 (100)
- The change in climate and weather [b]	2 (6)	0 (0)
- The rotation of the moon on its axis [b]	9 (26)	0 (0)
- The Moon moves around the Earth [b]	4 (12)	0 (0)
b) The concept of day and night occurrence - Identify night time		
	15 (44)	32 (94)
	8 (23)	1 (3)
	3 (9)	0 (0)
	8 (24)	1 (3)

a. Scientific Concept b. Misconceptions

However, after AR treatment, all students were found to be able to provide accurate answers related to daylight and evening phenomenon triggered by rotation of the earth on its axis. Also, one of the most common misconceptions is to identify day and night based on the position of the earth and the sun. A look into participant's answers, it was found that majority (44%) able to provide an accurate answer on the day and night on the earth based on the position and direction of the sun. After learning through AR, the post-test for this concept shows that the percentage for accurate answers increased to 94%.

Table 3 shows the conceptions of phases of the moon of participants before and after using AR. Looking into the answers given by the participants to answer questions about the concept of the occurrence of the phases of the moon; it found that only (6%) participants were able to provide the correct answer. The majority (79%) provide misconceptions concept by assuming that the periods of the moon happened because the different moon position during revolving around the sun. Besides, there were also 12% of the participants who give misconceptions answer by assuming that the phases of the moon occur due to the earth moves around the sun. However, after learning through AR, majority of participants (85%) were able to give an accurate answer, and only 15% of participants remained with misconceptions answer despite having undergone treatment sessions with AR. For the concept of phases of the moon through the diagram, it was seen that before learning through AR, none of the participants was able to draw the correct diagram to indicate the phases of the moon. Majority of the participants (68%) showed an incorrect diagram in terms of position while (32%) showed incorrectly diagram in terms of size and position. After learning through AR, the findings showed that most of the participants (88%) able to draw the correct diagram in term of position, size, distance and label. However, there are still a few participants (12%) didn't correctly draw the diagram.

Table 3. Student's understanding about the periods of the moon

Conceptions	Pre-test *f* (%)	Post-test *f* (%)
a) Different Moon stages because of...		
- Different moon positions during revolving around the Earth[a]	2 (6)	29 (85)
- different Moon position while revolving across the Sun[b]	27 (79)	5 (15)
- the travel of the Earth revolves around the Sun[b]	4 (12)	0 (0)
- rotation of the Sun on its axis [b]	1 (3)	0 (0)
b) Design of Moon Stages		
Draw the Earth-Sun- Moon position during the New Moon		
a  The position, distance and label are accurate	0 (0)	30 (88)
b  The distance and label are accurate, but then the position was inaccurate	23 (68)	4 (12)
b  The position and size are not accurate	11(32)	0 (0)

a. Scientific Concept b. Misconceptions

First of all, through 3D learning: AR application was developed using 3D objects as virtual models to represent learning content such as the earth, the moon and the sun that can enhance learning experience. With this unique ability of AR, it allows students to use 3D virtual objects to enrich the visual perception of the existing environment [21]. AR provides three-dimensional objects that are commonly seen objects in the real world into student learning. The information presented through texts and images in printed book in two-dimensional form lost the real-world elements and made the interpretation difficult for some students. The 3D animation virtual objects can be viewed, observed and manipulated from different perspectives to improve students' understanding [22].

With the unique capabilities of AR to create a 3D model or information imposed toward reality, it could strengthen the student's imagination. Imagination and spatial visualisation abilities among primary school students are generally very limited [23]. Additionally, learning of science subjects that require high imagination, the use of AR can help students in describing abstract science concepts or difficult phenomena that hard to be seen and observed using their naked eyes. AR allows students to manipulate virtual objects or observe phenomena that are difficult to see in our natural environment. This learning experience, in turn, encourages student-thinking skills and understanding of concepts in abstract phenomena can also be enhanced and correct misconceptions. AR also supports the comprehension of abstract concepts by providing unique visuals and interactive experiences that combine real and virtual information and help deliver abstract problems to students effectively. With AR, instructors can generate virtual objects/graphics with real-world environments that allow students to interact physically with digital content. Hence, the delivery of AR can help students understand the concept more effectively. For example, students may find it difficult to understand the position of the earth from the sun by simply reading the text and looking at two-dimensional images, but they can increase the understanding of the concept with the use of three-dimensional animation provided by the AR.

Besides, among other factors that might contribute to the conceptual change was due to advantages of AR application developed in the form of books with interactivity compared to traditional printed books. The interaction of AR objects was in real-time, which in turn can increase the perception of immediacy [24-26]. Future studies also could investigate the implementation of AR in mobile devices platform to the effectiveness [27, 28]. The students can control the books by rotating the book pages to view virtual objects from multiple angles and perspectives or by turning the pages to display varying AR content. This technology can enhance learning with traditional printed books by offering new methods for understanding the content. The interaction and spatial visualisation capabilities offered by AR books are seen to be beneficial to the learning process.

4. CONCLUSION

This research aims to explore the augmented reality (AR) implication toward primary school students' conceptual change of science concepts. We examined conceptions of primary school students about three topics in science before and after learning through AR application. The AR application consisted of 3D animation virtual objects of three targeted astronomy concepts: Travel for earth, moon and sun that cause daylight and nighttime happening as well as the stage of moon. Findings demonstrated that before learning through AR, primary school students had some misconceptions on those topics. However, after learning through AR, most primary school students were able to shift from misconception to accurate explanation of the content. The findings of study demonstrate AR for learning was considered effective in facilitating conceptual change. The effects of research allow the teacher to support their pupils using AR system acquiring new conceptual knowledge and correct their misconceptions. There is drawback of the study that needs to handle in the future, which is closed observation in small groups to identify the detail implication of AR toward pupils learning performance.

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