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The Assimilation of Augmented Reality in Learning Environment

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Abstract

The pandemic Covid-19 has led the Malaysia Government to execute the Movement Control Order (MCO) in which resulted in the closings of all schools. Due to this matter, to furnish all the student learning needs. The learning paradigm has to shift from a face-to-face approach to a non-face to face approach. The Ministry of Education (MOE), Malaysia recommends all schools under MOE to use Open Distance Learning (ODL) which is part of the e-learning process. The advancement of the Internet of Things (IoT) and the integration of technology know-how, will make every aspect of learning possible. This study goes some way to bridging the gap by exploring students' engagement and motivation towards Augmented Reality (AR). Findings showed encouraging learning outcomes as quantified by data analysis. This unique feature of Augmented Reality had led it to be implemented in education as it can convey abstract knowledge to a comprehensible context. Augmented Reality provides a fascinating learning environment as it increases the motivation and attractiveness of teaching and learning in real-life scenarios for students.

Keywords **-** *E-Learning, Augmented Reality, Multimedia Elements, Learning, Motivation*

1. Introduction

The advancement of technology in this day and age has simplified the way of how students learn. This provided less cognitive load and increases student productivity in the pedagogical process. Furthermore, the aid of technology is needed and useful to decipher abstract information in an understandable context in subjects that has a lot of reading or contain texts and facts in a textbook. In addition, integrated learning technology promotes motivation (Hsiao, S.H., et al., 2016), provides the opportunity to develop one's knowledge (Pribeanu, C., et al., 2016), enhance teamwork, and encourages higher thinking skills and creative thinking skills (Ng, K.T., and Correnna, A.T., 2013). Learning is where students gain experience and knowledge for them to apply in future endeavours in real life.

As stated before, technology has become part of our life and in education, technology is required to make learning easy and accessible by everyone. An example of the use of technology is the recent Coronavirus or Covid-19 pandemic outbreak in Malaysia. With the school closure to contain the pandemic, the Ministry of Education (MOE), Malaysia has encouraged the students to do (Online Distance Learning) ODL or better known as e-learning (Mohamad Idham Md Razak, 2020). With applications such as Zoom or Google Meet, the digital learning environment can be accessed anywhere by the students and teachers so that they would not miss their lessons. This corresponds with the Sustainable Development Goal in Education which is to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". Although through

e-learning, the teacher could not insert their presence as well as being physically in classes to ensure their students learn and understand the subject (Hetsevich, I., 2020) Thus, several teaching methods have been suggested to increase the student motivation and understanding especially in subjects that have a lot of facts or texts. One of those methods is the use of Augmented Reality (AR). AR has been suggested to incorporate multimedia elements and other theoretical guidelines, and with the guidance of the teachers, students can understand abstract information and reducing their cognitive load. The use of AR in education in Malaysia needed more focus and should be looked into further as there is more potential to be discovered about this technology as this technology is being less used in Malaysia (Farhana Nor Shuhada Muhammad Pozi, & Fariza Khalid, 2017). Ching, N. C. and Chandrashekar, R. had stated that the researcher had disclosed that there are only 44% of Malaysians knew about AR technology (Ching, N. C. and Chandrashekar, R. 2018). In addition, Nur Aniza, M. L. and Khairul Aidil, A. R. had stated that only 34.75% of Malaysians knew how to use AR (Nur Aniza, M. L. and Khairul Aidil, A. R., 2015). However, the same study had revealed that, even though the rate of familiarity with the AR technology is low, the respondents had shown great interest to learn more about the AR technology despite the lack of equipment or information in Malaysia. E-learning and Augmented Reality compliments each other. With the Covid-19 outbreak, students may have a hard time understanding subjects that are being taught through online learning especially subjects with abstract information. Therefore, the use of Augmented Reality can transform the information into multimedia to assist the student understands better even without the physical presence of their teacher beside them (Farhana Nor Shuhada Muhammad Pozi, & Fariza Khalid, 2017). However, the use of Augmented Reality is not meant to replace the teachers as they are still the most valuable asset in education but with their guidance and use of technology, it can improve the learning and teaching quality (Farhana Nor Shuhada Muhammad Pozi, & Fariza Khalid, 2017). Thus, this paper aimed to create an AR learning application and examine its effectiveness towards the e-learning pedagogy in selected primary schools in Klang Valley, Malaysia.

2. Augmented Reality

Augmented Reality (AR) technology has been used widely in this era of Industrial Revolution 4.0. As shown in Figure 1, AR is one of many Reality-Virtuality (RV) Continuums that have become an impressive technology over the past few years. Augmented Reality permits the end users to view the whole perspective of the world with the superimposed technique. The usage of AR utilizes the elements of multimedia such as imagery, animation, audio, and video to enhances the user's perception (Olsson, T., 2012). In the early days of Augmented Reality, it uses Head-Mounted Displays (HMD) and few other components to help the system displays the virtual object in real-time as this can be seen with ARQuake (Mukherjee, S., 2018). In recent years, Mobile Augmented Reality (MAR) began to emerge that utilizes the capability of smartphones (Android & iOS) and utilizes its camera as the basis to perform AR functions (Mukherjee, S., 2018). This can be seen with Pokemon Go, a mobile game application utilizes the capability of Augmented Reality in smartphones. During its first launched, it has become a phenomenon all around the world with over 550 million downloads and made Augmented Reality well known among the masses (Kari, T., 2016). Augmented Reality can be viewed through a screen display such as a webcam, smartphone, or a head-mounted display.

However, in education, the use of gadgetry such as a smartphone is considered to be the best option as in several kinds of literature (Kari, T., 2016), Sharma, H.L., (2016) had emphasized the use of Mobile Augmented Reality (MAR) application. This is because, in today's technological advancement age, the widespread use of mobile devices plays a significant role in education and sees the effects and benefits of these devices in terms of pedagogical perspectives (Sharma, H.L., 2016). The rapid increase of mobile device usage over the years had led to the possible development of Mobile Augmented Reality (MAR) (Sharma, H.L., 2016). There are two types of Mobile Augmented Reality trigger in which they are markerless and marker-based. Markerless AR does not need any 'anchor' in the real world while Marker-based AR required an 'anchor' for it to display its content. Several research Kari, T. (2016), Isabelle, C. (2017) encourage the use of marker-based AR in combination with textbooks for effective pedagogy. Marker-based AR extracts embedded information based on its 'anchor' and displays the virtual object in real-time.

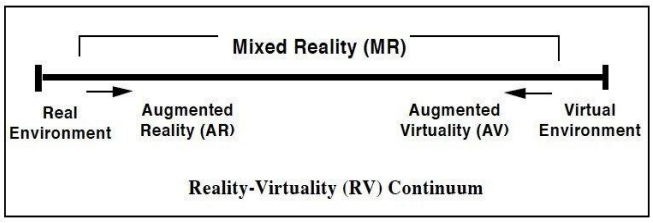

Figure 1. Milgram and Kishino's Mixed Reality on the Reality-Virtuality Continuum (1994)

3. Multimedia Elements

In accordance to Pulasthi, G. (2016), multimedia can be defined as numerous media elements being integrated together for one whole lesson, delivering satisfying results for its end user. The use of multimedia in education has been shown to have a significant effect on student academic performance in a meaningful learning environment through the integration of numerous media Sharma, H. L. (2013) and Almarabeh, H., Amer, E., and Sulieman, A., (2015). The use of multimedia in education has been proven to be relatively successful as it utilizes more than one of the five (5) human senses by using two (2) fundamental sense vital for information reception – sight and sound Almarabeh, H., Amer, E., and Sulieman, A., (2015). It can also spark attention, motivation, and encouragement in the learning process due to the presence of motion and sound Almarabeh, H., Amer, E., and Sulieman, A., (2015). Multimedia on its own, on the other hand, is intriguing at best and does not necessitate the user being consciously controlling or concerned about what is being portrayed.

In relevance to (M. Siti Zaharah, 2018), (Kamaruzaman, M. F., & Zainol, I. H., 2012), Kamaruzaman, M. F., Azahari, M. H., & Anwar, R., 2012) and (Rani, N. M., Zainol, I. H., & Kamaruzaman, M. F., 2015), multimedia education program would accommodate hypermedia applications such as visuals, texts, animation, video, and audio in which it utilizes all of the human cognitive and aims to inspire the students in the learning process. With these elements been used in teaching and learning, it will make teaching and learning more enjoyable. Texts are an important communication for any medium as it conveys the information in an understandable form. The use of visual imagery helps to capture the attention of the students. According to Alessi, S.M., and Trollip, S.R., (2001), categorized visuals into four major applications namely, analogies, primary information, cues, and organizers. Audio is the use of sound to attract the students' interest with the use of music, speech, or sound effect (Alessi, S.M., and Trollip, S.R., 2001). The use of video in conjunction with audio can be appealing where visual sound presentation facilitates better comprehension than reading the text. Besides that, using animation will add a visual effect to the multimedia presentation in order to make the students much more engaged with the lesson. This makes it an interactive multimedia, creating an immersive learning environment. Multimedia helps to explain how learning takes shape by providing real-world insight, improving continuity by the use of many different audio-visual aids and, ultimately, developing a robust learning environment Pulasthi, G. (2016).

4. Education Theory

4.1 ARCS Motivation Theory

The ARCS model (Keller 1983) is a motivational design framework that involves a combination of motivational principles and theories that are grouped into four (4) categories in which they are attention (A), relevance (R), confidence (C), and satisfaction (S) (Khan, T., Johnston, K., and Ophoff, J., 2019). In regarding the ARCS theory that focuses on motivation, it is an important factor in promoting and maintaining self-regulated learning which also leads to better academic performance (Steinmayr, R., Widinger, A.F., Schwinger, M., and Spinath B., 2019). The use of attractive, satisfying, and stimulating material for a pedagogical process., such as AR with multimedia, will motivate the students in the pedagogical process (Nincarean, D., et al., 2013). Following McKivigan, J. (2019), the ARCS model emphasized the motivational aspects of the learning process. As stated previously, ARCS is divided into four factors that influence the motivation of students in which are Attention-Relevance-Confidence-Satisfaction (ARCS) (Khan, T., Johnston, K., and Ophoff, J., 2019). The factors were

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generated by grouping motivational terms together based on similar characteristics. The categories and subcategories serve as a foundation for evaluating learner motivation characteristics and deciding how to develop motivational techniques and learning environments that enhance and maintain people's desire to learn (Khan, T., Johnston, K., and Ophoff, J., 2019). Attention is to stir up student interest, maintain student focus, and stimulate student curiosity. Relevance is the creation of appropriate personal recognition by students based on studying new textbooks and previous experience. Confidence is where the aspirations of the student were awakened and positive attitude towards the students to help them develop confidence in themselves. Finally, Satisfaction is a sense of satisfaction gained by the students and learning outcomes should improve their success in self-learningg.

4.2 Cognitivism Theory

The theory of cognitivism claims that one can open and consider the mind "black box". By accepting new ideas, the learner is seen as a processor and a very involved participant in the learning process Ertmer, P.A., and Newby, T.J., (1993). This theory focuses on conceptualizing the learner learning process and discusses the issue of how the mind receives, organizes, stores and retrieves information Ertmer, P.A., and Newby, T.J., (1993). The integration of cognitivism and visualization will provide the students with a new and creative learning experience. Furthermore, the transfer of knowledge during the cognitive process will in the most effective manner as possible Ertmer, P.A., and Newby, T.J., (1993). The cognitive theory focuses on the mental processes by which a learner receives, interprets, stores, and retrieves data. Between stimulus/input and responses/output, these mental processes take place. The person receives the stimuli, processes it in their mind, and then reacts to it. Attention, listening, perception, interpreting, arranging, memory (storing and retrieval), categorising, and making generalisations are some of the mental processes that are involved Ertmer, P.A., and Newby, T.J., (1993).

4.3 Cognitive Theory on Multimedia Learning (Mayer's)

Richard E. Mayer and other researchers popularize the Cognitive Theory of Multimedia Learning (CTML) which argued that multimedia supports the way the human brain learns. In this theory, it defines five cognitive processes in multimedia learning in which they are selecting relevant words from the presented text or narrative, selecting relevant images from the presented graphics, organising the selected words into a coherent verbal representation, organising selected images into a coherent pictorial representation, and combining the pictorial and verbal representations Mayer, R. E., (2001). Underlying this theory is the assumption that the structure and functions of the human mind should be based on the instructional design. The main objective of CTML is to create meaningful connections between pictures and words for the learner to grasps them more profoundly than they do with words or pictures alone Mayer, R. E., (2001). Figure 2 presents the framework for the Cognitive Theory of Multimedia by Mayer, R. E., (2001). This reveals that within the theory the system has four (4) channel phases that include interactive presentation, sensory memory, working memory, and long-term memory.

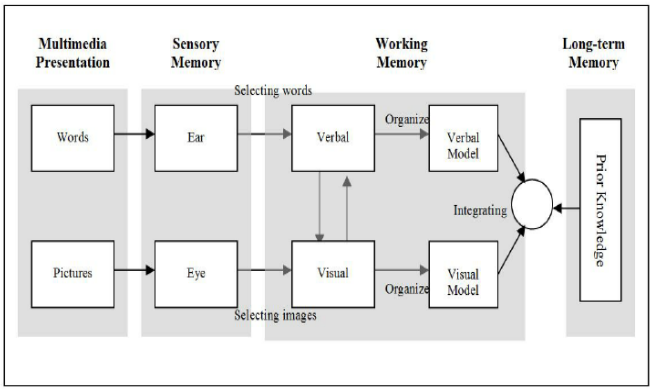

Figure 2. The Cognitive Theory of Multimedia Mayer (2001)

With the CTML model, it shows how multimedia learning through AR can improve a pedagogical process. Nevertheless, AR can be prone to exposing too much information or context for its user from the environment by creating a cluttered display. This can hamper the user cognitive ability of selecting and organizing as there is so much information for them to analyze (Mayer, R. E., 2005). Therefore, in order to maximize the potential of AR, several multimedia principles are needed to go against a cluttered AR visual. CTML has 12 multimedia teaching concepts that can be used to design and build a practical multimedia learning process Mayer, R. E., (2001). However, Mayer, R. E., (2005) had stated that AR incorporates 5 of those principles: multimedia principles, spatial contiguity principle, temporal contiguity principle, modality principle, and signaling principle, as shown and explained in Table I below. These principles were used to reduce extraneous processing as Mayer's CTML relied heavily upon cognitive load theory.

Table 1. Augmented Reality Multimedia Principles

Principles	Descriptions
Multimedia Principle	Texts and visual would help the learner to learn and understand better.
Spatial Contiguity Principle	People learn better when correspondent words and pictures are closer together rather than further apart.
Temporal Contiguity Principle	As similar words and pictures are viewed together, people understand faster, rather than farther apart on a page or screen.
Modality Principle	People learn better by presenting textual information in auditory format when accompanying related visual content.
Signalling Principle	People learn better when adding signs that underline the organization of the important materials.

5. AR Learning App Development

5.1 Incorporated *Theories and Model*

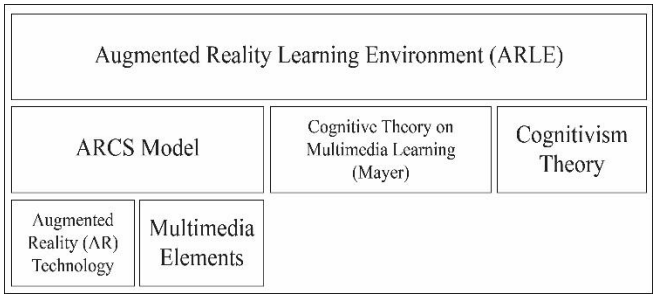

Figure 3. Incorporated Theories and Model

Based on the existing studies, the researcher has come up with a conceptual framework that incorporates learning theories and model in the development of the Mobile Augmented Reality (MAR) app. The model follows the same model framework as Valarmathie, G., Juliana Aida, A. B., and Abdul Nasir, Z. (2017) with small adjustments to better fit the research study. Therefore, as shown in Fig.3, to create an effective AR Learning Environment (ARLE) for the MAR learning application, the ARCS model along with AR technology and Multimedia Elements, Cognitive Theory in Multimedia (Mayer's), and Cognitivism Learning theory were implemented in the development of AR application. These models, elements and theories were used as the fundamental to create a working MAR prototype for the respondents to use.

5.2 Working System Model

Once the working system model has been developed, it provides augmented video, visuals, and audio for the students to learn History through Augmented Reality. It is developed with the intention to support the students to learn and improve the pedagogical process to ensure an effective learning environment. We proposed a marker-based AR by using mobile phones to learn the subjects using augmented multimedia. An android phone is required to execute the application. The system model consisted of the marker image alongside with textbooks content that contain abstract information. The students then use the Augmented Reality app to scan the marker in which it will play visual representation (videos and imagery) that is related to the texts to help the students understand the subject better. The initial application has been constructed by using Unity3D and Vuforia Augmented Reality (Vuforia AR). Later it will be tested to the end users for verification. The assets of the AR will be created by using Unity3D while the coding and execution will be done by using Vuforia AR to link the tracker image to its database. Once the camera is being pointed at a marker image, it will scan the image and then process the data that is tied to the image from the application database. Once the marker is recognized, it will then render the model database and then tracked to the marker itself. In Fig 4, it shows the system architecture on how the model works. In Fig 5, it shows the screenshot of the working model that executes an augmented video.

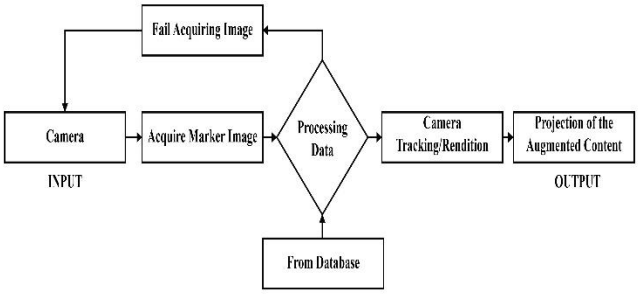

Figure 4. System Architecture of Marker-Based AR

Figure 5. Augmented Video

6. Methodology

It is a research that define the educational possibilities of teaching in AR as a part of improving the current pedagogical approach. This study will fabricate the same model of study (Kamaruzaman, M. F., & Zainol, I. H. , 2015) by using the user experience assessment model. Survey and interview were developed systematically and divided into several sections and have been compiled by using factor identified in the state-of-the-art (Kamaruzaman, M. F., Azahari, M. H., & Anwar, R., 2012) . Due to the pandemic outbreak, the survey has been conducted via online towards the selected primary school in Klang Valley, Malaysia. A total number of 90 school students participated in the testing of AR learning app. A total number of 90 school students consisted of both male and female students with ages from 9 to 12 years old from Sekolah Kebangsaan Sungai Udang, Sekolah Kebangsaan Telok Gadong, and Sekolah Kebangsaan Teluk Pulai had participated in the use of MAR application test. Due to the COVID-19 pandemic, to comply with the Standard Operation Procedure (SOP) from the Ministry of Health, the test was conducted online via Google Meet. The Table II below shows detailed demographics of the students.

Table 2. Students Demographics

Gender	9 Years Old	10 Years Old	11 Years Old	12 Years Old
Male	10	11	8	6
Female	17	15	11	12

The respondents were exposed to the MAR application prototype and how to use it. The fundamental rationale behind this approach is specifically to collect data relating to the frequency of phenomenon. A set of questionnaires was developed specifically for this purpose. The questionnaire consists of five (5) questions that are relation to the students experiences in using the MAR application. The MAR app allowed students to scheme and scanning the information they could use for knowledge revitalisation (Kamaruzaman, M. F., Azahari, M. H., & Anwar, R., 2012) and Rani, N. M., Zainol, I. H., & Kamaruzaman, M. F. (2015). This MAR app allowed the students to seek the information in a diverse environment. Hence, it gives a different learning atmosphere to the students. After gathering all the information, analysis of the survey was conducted to conclude the investigation needed.

7. Results and Discussions

The use of the Augmented Reality (AR) app has been evaluated through the use of mobile smartphones. All of the respondents were given a thorough explanation that are related to Augmented Reality before experimenting with the MAR app. Most of them do not know what Augmented Reality is or how to use it but shows great interest after being exposed. This is because for them, it is their first time in experiencing a new technology as well as learning style. All of the respondents were able to complete the task with minimal supervisions. Figure 6 to Figure 10 shows the data analysis of the questionnaire that has been provided. Majority of the respondents

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were curious to what is AR at first but then shows interest and able to use it after a thorough instruction. The content of the AR was easy to go through without any distractions.

The following pie charts are the analyses of information from the questionnaire.

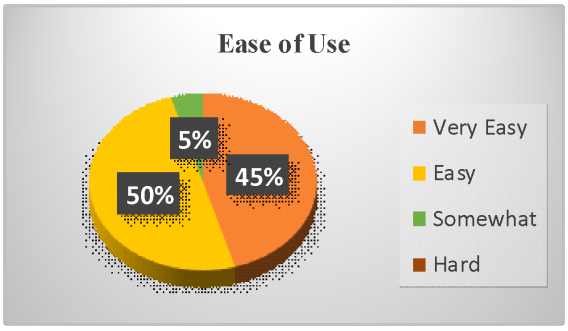

Figure 6. AR App Ease of Use

Figure 6 showed that majority of the respondents find the Augmented Reality (AR) Learning app is easy to use while the rest are feeling neutral about it, but none said that it was hard to use. The researcher had taught them on how to use the Augmented Reality beforehand, but the respondents quickly learn on how to navigate through them. This shows that using the Augmented Reality app does not require a steep learning curve and can be learnt in a short amount of time as the Augmented Reality technology is straightforward in use. Even though the test were organized online, the students still understood how to use them even without the researcher had to physically be there to explain it to them.

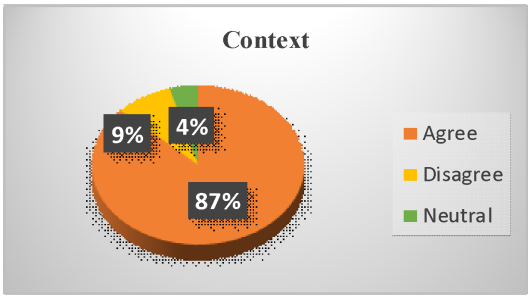

Figure 7. Do Respondents Understand the AR Learning App Context

Figure 7 showed that majority of the respondents agreed that they understand the context better with the use of Augmented Reality than reading the text alone. This is because reading the texts can cause the respondents to be bored or not to understand what the texts is trying to convey as they are mere 'words' and cause the respondents to have a cognitive overload. Using the Augmented Reality with multimedia elements such as sound, images, and video helped the respondents to comprehend the context through visual or verbal representation that led to a deeper understanding. By using the combination of augmented multimedia while reading the textbook, it increases the students.

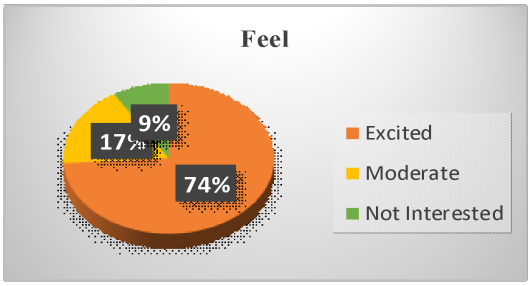

Figure 8. What Respondents Feel When Using AR Learning App

Figure 8 showed that 74% of the respondents are excited about using the Augmented Reality app as it was fun to them as they could see the augmented visual in real-time that translated abstract information into an understandable context. The multimedia incorporated in the Augmented Reality app impacts the respondent moods during the learning process. Experiencing positive emotions during learning can lead to a better pedagogical process. This happens because based on the researcher observation, using MAR to learn is a whole new experience for them. They can read the textbook while augmented video explains the context. This interactive way of learning helps them to comprehend the information better than just reading it.

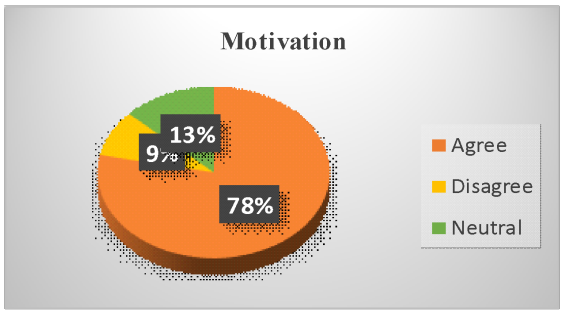

Figure 9. Learning Motivation in Using AR App

Figure 9 has shown that the majority of the respondents agreed that the use of the Augmented Reality app makes them feel motivated to learn. Having to experience Augmented Reality apps during the learning process increases the motivation of the respondents as they can understand the abstract information through multimedia implementation. This is because the augmented video, visuals, and audio, explains the context of the abstract information. The students can switch in between reading, and hearing or looking at the augmented object to maximize their cognitive ability without experiencing overload. With increases in motivation, Steinmayr, R., Widinger, A.F., Schwinger, M., and Spinath B. (2019) had stated that it can help the students to improve their achievement in academics.

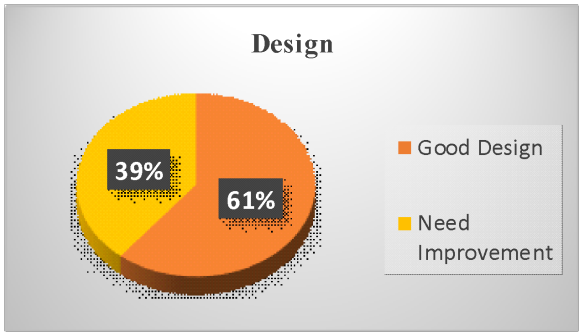

Figure 10. What Respondents Think About the AR User Interface Design

Figure 10 has shown that 61% of the respondents said that the AR app has a good design but 39% of the respondents thinks that the app design in terms of visuals and augmented object can be improved further to attract more interest. A well-designed Augmented Reality in terms of User Experience (UX) and User Interface (UI) design can further improve the pedagogical process as well as the reliability of the app itself. Even though the UI was made not to be cluttered with needless information, the respondents feels that something that is lacking but did not deter them to use it. A bad UX/UI design can render technology useless and unusable thus it could not deliver its objective to the users.

8. Conclusion

The aimed of teaching and learning in Education 5.0 are to educate the current and future generations to be creative, innovative as well as have a good command in technology. The use of AR Learning App as an instructional tool in enhancing theoretical subjects may carry a significant impact on primary school student pedagogy. Besides, the AR platform emerges as exciting and motivating approach to deliver the learning process development. Students who are enthralled with AR technology in the end find this platform vibrant and dynamic.

It is also noted that AR technology envision to improve the life-long learning by offering the students an ample time to practice the knowledge that has been delivered in class session, thus they will be engaging in significant learning activities to disseminate the knowledge itself.

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