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A Brief Review of Augmented Reality Science Learning

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Abstract. This paper reviews several literatures concerning the theories and model that could be applied for science motivation for upper secondary school learners (16-17 years old) in order to make the learning experience more amazing and useful. The embedment of AR in science could bring an awe-inspiring transformation on learners' viewpoint towards the respective subject matters. Augmented Reality is able to present the real and virtual learning experience with the addition of multiple media without replacing the real environment. Due to the unique feature of AR, it attracts the mass attention of researchers to implement AR in science learning. This impressive technology offers learners with the ultimate visualization and provides an astonishing and transparent learning experience by bringing to light the unseen perspective of the learning content. This paper will attract the attention of researchers in the related field as well as academicians in the related discipline. This paper aims to propose several related theoretical guidance that could be applied in science motivation to transform the learning in an effective way.

INTRODUCTION

Technology simplifies the process with less cognitive effort and enhances the productivity. Therefore, the assistance of technology in the main domains, especially in education is widely welcomed. Moreover, technology is needed and very useful in pure science, physics, chemistry and biology to simplify plenty of complicated and complex scientific terms and processes. Without the aid of technology, it is tough to convey the exact meaning of the learning content and to make learners understand. Besides that, technology integrated learning technique cultivates motivation [1], [2], enhance collaboration, provide the ability to construct their own knowledge [3], [4], stimulates higher order thinking (HOT) skills and innovative thinking in the learning process [5].

Learning is a platform to gain experience, knowledge and to master the skills to be applied in the future endeavours in real life instead of memorizing the facts without any understanding [6]. According to [7], [8] technology and education are correlated and have a positive relationship for a long time, but there is no medium or force to present it parallel with more dynamic and energizing. In addition, the multiple media integrated learning application offers a new bright light into the learning process and forces learners' to represent information and knowledge in a new and innovative way [9], [10]. Therefore, Augmented Reality (AR) with the addition of multimedia elements and several theoretical guidance has been proposed to enhance learners' science motivation in order to provide a learning experience beyond belief and expectation.

MULTIMEDIA IN EDUCATION

Multimedia (MM) defined as "a strong blend of technology that comprises an extraordinary of machines to assist the educational process" [11]. [12] claims the "promise of multimedia learning is that teachers can merge the power of visual and verbal forms of expression in the service of promoting understanding of learners". It is proven in a tangible learning environment with the implementation of multiple media in education positively influences student academic achievement [13], [14].

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Multimedia consists of five core elements (text, audio, graphics, video, animation and video) with the addition of three dimensional models. These elements make the learning process easy, interesting and allow the creative works [14]. Text is the easiest and fundamental method for conveying information and presenting ideas. Text plays a prominent role in presenting the information [15]. Text is the simplest element to transform information in an effective and helpful output yet also can be vague and meaningless output. Furthermore, [16] categorized graphics into four major applications namely; as the primary of information, as analogies or mnemonics, as organizers and also as cues. The use of graphics enhances the appeal, interaction and grabs the learners' direct attention. Audio is a sound or noise that can grab learners' attention and distract their focus immediately from his or her current activity. [15], [16] indicated that a video can be appealing and provoke. The combination of visual presentation with audio explanation enhances the understanding much better than only reading the content [17]. According to [18], animation is a brilliant way to add visual impact to the multimedia presentation. Animation is the additional effect that added to the materials to make the learners engage with the animation action using a mouse and a keyboard. Multimedia becomes interactive multimedia when comprised with interactivity. The interactive multimedia involves digital storytelling in all of its aspects, visual innovation, and computational creativity with the combinations of electronic texts, graphics, moving images, and sound, into a structured digital computerized environment that allows users to interact with the data for appropriate purposes [18].

AUGMENTED REALITY

Augmented Reality (AR) is an extended version of virtual reality abbreviated as VR. AR has a long history since the 1980's yet it is still in initial phase due to certain limitation in the technology, social acceptance [19], usability [19], finance, time constraint [20] and lack of awareness regarding the potential of the technology in education [21]. In addition, it comprises of three fundamental criteria proposed by the guru of the field for an AR application namely; a combination of real and virtual world, interactivity in real time environment and has to be registered in 3D [22]. [23] defines AR as "augmenting natural feedback to the operator with simulated cues". From the previous definition proposed by the experts in the field, AR can be simplified as a concept that reveals the intuitive contents that are not possible to practice and undergo in an existent circumstance.

Based on [23], AR is much closer to the real environment than the virtual environment. It depicts that AR technology is able to superimpose the virtual content as it exists in the actual atmosphere. The AR virtual learning content can be viewed through the use of several devices such as the head-mounted display (HMD), computer with a web camera, mobile, handheld devices (HHD) and Kinect. Based on the review of the literature, it is identified that currently the emphasis is on mobile AR application and applied in all main domains [24], [25]. Mobile devices fulfil the requirement of following the current trends and the device bridge the limitation of time and location in a learning process.

As shown in Figure 1, the marker-based AR learning extracts the embedded virtual content through the use of black and white rectangle marker [24], [26]. Meanwhile as shown in Figure 2, the location-based AR extracts the virtual content from the real world objects, buildings, places through the use of Global Positioning System (GPS) and WiFi positioning system [24]. Researchers in the field such [3], [24], [25] have proposed marker-based AR learning. Marker-based learning makes students stay in one place and proceed with the learning process. Meanwhile, [27], [28] have proposed location-based AR learning. Location-based AR learning provides the opportunity to bring along the device to find and view the virtual content.

There are several difficulties such as take time to recognize and render the information, to determine the difference navigating, the difference between the reality and virtual and to interpret the point [29] could be faced by the learners' if the application is not well developed [29] indeed mobile based AR application provides the learners the learning experience beyond expectation.

(AR in science learning)

The intervention of multiple elements such as 3D models, animation, graphics and audio display in a technology-integrated learning environment is crucial. Even though 3D models have the ability to attract learners, but a static model could not able to continuously engage learners in the learning process [30]. The fusion of 3D models, animation, video, and graphics with the addition of text and audio is able to enhance the understanding of the content [1], [3], [30].

The employment of AR in scientific learning procedures could provide more fruitful achievements in science learning. This is because science has a lot of complicated procedures and intuitive processes which are hard to imagine and understand in a correct way. Therefore, a supplementary learning with the addition of technology tool is needed to extract the intuitive and unseen learning contents to understand it in a correct way.

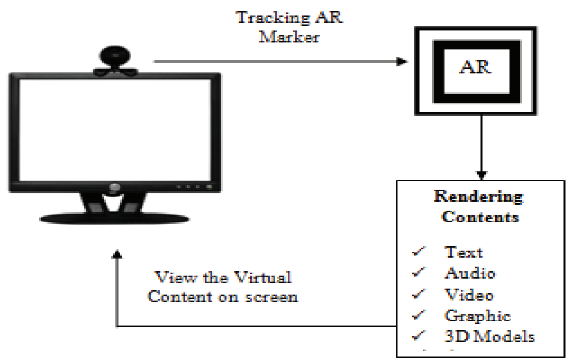

FIGURE 1. Marker-based AR

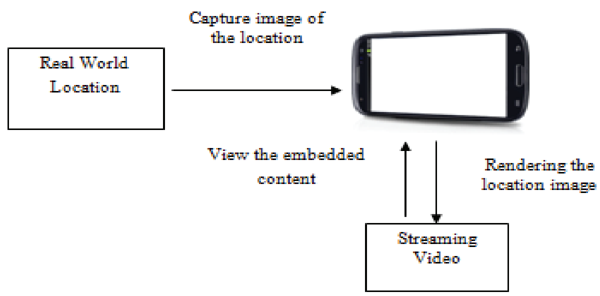

FIGURE 2. Mobile-based AR

MOTIVATION IN THE EDUCATION DOMAIN

Learners can be motivated directly through the use of attractive, satisfying and stimulating learning material [31], [32]. This is in line with the intervention of AR technology in addition to MM elements in this study to enhance learners' learning motivation towards science learning. According to [33], ARCS model is a systematic way to determine and deal with learning motivation. According to [32], learners can be motivated directly and grab the learners' attention through the use of attractive and stimulating medium or learning material. It is important to sustain and arouse the student's attention and curiosity in the learning process. Moreover, implementing novel, surprising, seeking facts by inquiry and provides variations in elements to gain and sustain learners' motivation [34]. Other than that, the goals of learning can be accomplished by facilitating the learning process utilizing simple words and examples or facts related to real life and arranging the learning strategies related to the student motivation [34]. Learners would feel confident and enjoy by having the awareness and knowing the probability of success, a level of the challenge and the feedback after completing the task successfully [34]. Finally, satisfaction occurs when learners are allowed to implement the new knowledge, accept feedback and consequences for the task accomplishment which then leads to positive outcomes to the attitudes [34].

COGNITIVE PRINCIPLES OF MULTIMEDIA LEARNING

More than anything, a good memory is crucial in a learning process. The cooperation between the multiple media in a learning process might enhance the learners' long-term memory for storing information and knowledge. Besides that, learners learn more and deeply with word and graphic together rather than word alone [35]. In that case, multimedia instructions comprised of twelve learning principles and categorized into three cognitive processes [35]. The cognitive processes are reducing extraneous processing, managing essential processing and foster generative processing [35].

There are five principles that have been included in reducing the extraneous processing of the cognitive process. The principles include; the Instructional Goal of Coherence, Signalling, Redundancy, Spatial Contiguity and Temporal Contiguity. Coherence and Signalling principles are aimed to delete extraneous material and highlight more on essential materials respectively. Learning is better when the extraneous words, pictures, and sounds are excluded [35]. By adding extraneous materials in multimedia learning presentation, it could divert the attention from the important materials and can disrupt the materials' organizing process. Other than that, redundancy principle illustrates that learning from animation and narration is better than from animation, narration, and on-screen text [35]. In a multimedia presentation, the visual channel can become overloaded when words and pictures are both visually presented as animation and text. Spatial contiguity principles illustrate that words and pictures should be placed closer rather than far from each other on the page or screen [35]. This eases the memory to work together at the same time. Lastly, temporal contiguity in a multimedia learning presentation presents the corresponding words and pictures simultaneously rather than in sequence [35]. If the related words and pictures are separated in time, the learners are less likely to hold a mental representation of both in working memory and also to build mental connections between both verbal (word) and pictorial (image) models.

Furthermore, managing the essential processes is the second cognitive process and comprised of the segmenting principle, pre-training principle and modality principle [35]. The segmenting principle was introduced in order to avoid the instructional overload and break the lesson into a learner-paced part. These attempts encourage learners' to have an in-depth knowledge and greater understanding on what they have learned. Moreover, the pre-training is to make the learners' have an idea and aware of the key concepts regarding the lesson before enduring in the actual lesson [35]. The modality principle depicts that animation and narration are better for learning than from animation and on-screen text whereby the learners could learn better when words in a multimedia presentation are presented as spoken text rather than printed text [35]. [36] have found that learners' performance got better in transferring the knowledge after they have experienced a lesson narrated with animation with the same words compared to the conventional teaching method. Hence, this principle has been introduced to make the learners' experience a better knowledge transfer when they share the knowledge with their mates.

Lastly, the foster generative process is the last cognitive process and includes the personalization principle, voice principle, implementation principle and image principle. All these four social cues play the main role in enhancing learners' motivation to make an attempt in order to make the material meaningful and logic [35]. The personalization principle uses the words as in conversational style rather than in a formal style. This technique of using conversational words included in learning leads to a deep engagement in the learning process because they will understand the lesson more and easier for them to connect it with real life relevance [35]. Moreover, the voice principle depicts that utilization of the human voice in materials better than the voice of a machine [35]. The implementation principle depicts that the existence of an on-screen avatar as like human to conduct the learning process like a teacher or as an instructor to guide the lesson [35]. Finally, the image principle has been included in order to avoid putting two-dimensional static images that represent the voice. It would influence the learners' focus and distract their attention from the lesson and did not perform any enhancement in learners' performance [35]. Learners can experience a better knowledge transfer from the technology through the media to learners and sharing knowledge among student to learners.

CONSTRUCTIVIST THEORY

Constructivism is a paradigm that depicts learning as an active, developing process of understanding, knowledge, and experience with the learners themselves based on their prior knowledge. This theory of learning leads to an active participant and learning by doing in the lesson. The learners as the information constructor linked the prior knowledge with new information. This theory was coined by Jean Piaget in the 1980s' [37].

Hence, active participation is crucial in science learning [38] and this constructivist learning theory permits that for the learners based on their prior knowledge. The combination of constructivist and visualization provide an innovative learning experience to the learner [39]. Other than that, constructivist learning provides the learner a real world experience and provides a positive learning experience [40]

CONCLUSION

The aim of our study is to design a comprehensive and effective AR learning environment for science motivation. The combination of technology with other elements, theories and model in science learning is to make sure the robustness of the learning experience last beyond time limitation and able to apply in real life. Therefore, as shown in Figure 3, ARCS Model, cognitive principles of multimedia learning and constructivist learning theory along with multiple multimedia elements and AR technology have been incorporated. Hopefully, through this learning experience, it triggers the learners' motivation towards science for their own good cause and to contribute the knowledge for the nations' economic development and industrial progress.

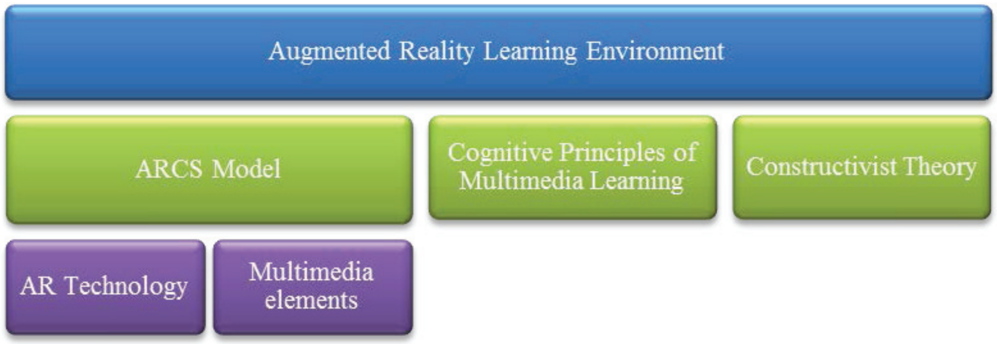

FIGURE 3. Incorporated Theories and Model

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