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AUGMENTED REALITY TECHNOLOGY FOR TEACHING -LEARNING OF SCIENCE IN SCHOOLS

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Abstract

Science education today is committed to producing human resources that have superior competencies and can compete in the global era. This is in accordance with the 21st-century education development paradigm, where learning outcomes of science are directed at critical thinking and problem-solving skills, creativity and innovation, collaboration and communication skills, and skill at using media, information, technology, and communication. Hence, it is believed that the adoption of Augmented Reality (AR) in science learning could improve interest, motivation and ultimately helps students to provide both conceptual and practical experiences in and around the subject of science. The purpose of this paper is to present a view of Augmented Reality (AR) technology as a significant tool for learning and teaching various subjects in general and science in particular. The review showed that Augmented Reality (AR) technology provides many affordances for Science learning; however, it is not ready for total integration into science classes. The paper also provides practical suggestions for activities enriched with Augmented Reality (AR) in science skills and recommended applications. This paper also offers various implications of AR technology around the teaching-learning process.

Keywords: *Augmented reality, Science Education, Augmented reality for Science learning, augmented reality for Science teaching.*

Introduction

Science education today is committed to producing human resources that have superior competencies and are able to compete in the global era. This is in accordance with the 21st-century education development paradigm, where learning outcomes of science are directed at critical thinking and problem-solving skills, creativity and innovation,

collaboration and communication skills, and skill at using media, information, technology, and communication. Therefore, school science curriculum and pedagogy should be designed and directed in such a way that students can fulfill the skills and abilities needed in the 21st century. Science teachers employ several materials in their lessons ranging from traditional course books to digital technologies. Competent teachers use modern technologies to a great extent to make their science teaching quite interesting, effective, and exciting. Computer software and tablet apps have obvious applications in classroom activities, but the technologies inherent in automated cameras, LCDs, and experiment monitoring systems can also aid in science education. With the availability of numerous digital tools, teachers now need to evaluate digital tools more meticulously. They need to have certain experiences with traditional course books also. Moreover, traditional course books are "relatively straightforward to evaluate because they tend to have a transparent structure allowing teachers to get an overview of the organization and content" (Hubbard, 2006). Technology can be used in education as a learning medium to support the learning process (Sirikaya & Sirikaya, 2020), Augmented Reality (AR) implementation is increased in education (Akcayir, Akcayir, Pektas & Ocak, 2016) because it is considered to be capable to display information in 3D which are too abstract if presented on the real learning process (Chen & Wang, 2017). Augmented Reality (AR) has many benefits and it can be used for all levels of education. Augmented Reality (AR) can facilitate the learning process (Enyedy, Danish & DeLiema, 2015), improve students' learning achievement (Estapa and Nadolny, 2015), satisfaction (Giasiranis and Sofos, 2017), and especially in chemistry learning can support practical skills (Yang, Mei & Yue, 2018) as well as conceptual understanding in inquiry-based scientific activities (Cheng & Tsai, 2013).

It can be stated that Augmented Reality (AR) is very helpful to improve the student's learning outcomes in the affective, cognitive, and psychomotor domains. These skills provide a framework for how scientists act, think, and deepen the problem to find a solution scientifically (Idiege, Nja & Ugwu, 2017). Science Process Skills (SPS) are important for students when using scientific methods to develop science and are expected to acquire or develop their knowledge (Sihaloho, Sahyar & Simanjuntak, 2017). Science Process Skills (SPS) are categorized into two types; basic and integrated (Arabacioglu & Unver, 2016). Basic process skills are aimed at primary school, while integrated can be achieved by medium and higher school students (Seetee, Coll, Boonprakob & Dahsah, 2016).

The success of the learning process is complex because it is also determined by the students, whereas the teacher only acts as their mentor (Dimyati and Mudjiono, 2006). Thus, the teacher should create good learning that can make students more active and explore their potential. Then, students can understand the science work methodology and develop certain skills in scientific work or science process skills and also have the competence to develop their knowledge. SPS can affect the development of students' knowledge (Rezba, Sprague & Fiel, 2003). Students need to improve their process skills to understand the chemical concept completely. Students with high science process skills (SPS) will highly master the concepts as well (Cetingul & Geban, 2011).

Basic process skills are used in this research including observing, classifying, communicating, measuring, predicting, and inferring (Shahali and Halim, 2010). The acid base is suitable for measuring science process skills (SPS) because it includes complex calculations and abstract concepts (Gultepe, Celik & Kilic, 2013). Therefore, to understand the acid-base concepts, students must be able to have several skills needed in learning chemistry such as science process skills (Irwanto, Rohaeti & Prodjosantoso, 2018). It is usually observed that learning media used in classes are usually books with two-dimensional forms, so they do not always provide all of the information to students, which makes students difficult to learn. AR has three main characteristics; 3D recognition, a mix of real and virtual worlds, and real-time interactivity. The success of the learning process is complex because it is also determined by the students, whereas the teacher only acts as their mentor. Researches reveal that science process skills affect the development of students' knowledge. Therefore, it is widely felt that students need to improve their process skills to understand the various concepts of science completely. Motivation and learning are two things that influence each other. Science process skills and Problem-solving skills are one of the main quality parameters of someone living in a modern society, which is very technical, scientific, and complex.

Augmented Reality (AR) technology allows virtual objects to be produced by computers to be placed on physical objects in real time (Ozdemir et al., 2018). Through Augmented Reality (AR) technology, students can study the objects of the earth's structure and phenomena that occur visually to form various types of rocks actively. In other words, Augmented Reality (AR) enhances the perception of the user and helps them to understand better (Iftene & Trandabat, 2018).

Augmented Reality in Education

Augmented Reality (AR) allows flexibility in use that is attractive to education. Augmented Reality (AR) technology can be utilized through a variety of mediums including desktops, mobile devices, and smartphones. The technology is portable and adaptable to a variety of scenarios. Augmented Reality (AR) can be used to enhance content and instruction within the traditional classroom, supplement instruction in the special education classroom, extend content into the world outside the classroom, and be combined with other technologies to enrich their application. Research shows that the use of Augmented Reality (AR), regardless of grade level or subject area, allows students to be actively engaged in the learning process. "Building and using Augmented Reality (AR) scenes combines active complex problem solving and teamwork to create engaging educational experiences to teach science, math, or language skills, and studies have found that this activity enhances student motivation, involvement, and engagement" (Billinghurst and Dunser 2012). Though most research shows the use of Augmented Reality (AR) in education through middle school science, there are some implementations in other subject areas and age groups. For example, Augmented Reality (AR) was utilized in a visual arts class as researched by Serio et al. (2013).

Augmented Reality in Science Teaching and Learning

Several image-based Augmented Reality (AR) applications have been designed for science learning. For instance, Martın-Gutierrez et al. (2010) designed an Augmented Reality (AR) book with marker identification, namely Augmented Reality (AR)-Dehaes, which utilizes iconic markers and offers 3D virtual objects displayed on the screen to help students to handle and visualize engineering graphics and further enhance their spatial ability. For inorganic chemistry education, the image-based Augmented Reality (AR) set up in a multimedia classroom could support students in developing spatial intuition regarding the 3D arrangement of crystalline structures (Nunez et al. 2008). Another image-based Augmented Reality (AR) applied with teachers' instructional guidance for geosciences in a classroom, which was employed by Kerawalla et al. (2006), required children to hold an Augmented Reality (AR) tile to manipulate the spatial relationships between the 3D objects of the Earth, Sun, and Moon. This learning activity was designed to help the conceptual understanding of biology. Concerning the enhancement of practical skills, Andu´jar et al. (2011) developed an image-based Augmented Reality (AR) remote laboratory to demonstrate to students the devices and enable them to interact with physical elements overlapped with virtual objects in

real-time. In discussing educational AR's efficacy in education, there needs to be boundaries and specifications as the technology itself is very distinct. A very limited number of Augmented Reality (AR) applications and content are available for language education. Mobile Augmented Reality (AR) applications can be grouped into three depending on their purpose, place of use, and usability.

AR-Based Learning Environment in Science Education

AR application provides a new perspective on the experimental activities performed in laboratories, which hold an important place in science education. Normally, students can use visual tools such as pictures, videos, or animation to learn about the physical structure and properties of a chemical element. The idea that AR provides factual life-connected information and provides versatile information supports that situation. AR also supports the teacher to better present new subject content, while students welcomed the visual material support provided by AR. In science education, laboratories are used for different purposes, including supporting the content and concepts taught in lectures, learning to conduct research, learning to conduct measurements, motivating students, and appreciating the experimental nature of science. Experimental activities provide versatile information. This allows students to observe abstract concepts. It Increases the involvement in learning providing students with opportunities to select their methods and pace of learning. In addition to active participation, AR is also effective in fostering interaction among students. In this respect, it can be an effective learning and teaching tool in structuring and recalling information.

The current generation of mobile devices already provides users with advanced features like location awareness, internet connection anytime-anywhere, touch screens, data recording, and processing. At present, practices relevant to mobile learning are shifting towards hybrid and augmented reality systems. It turns out that augmented reality possesses certain intrinsic features, that render it particularly appealing to be utilized in learning contexts. As both a cognitive tool and a learning approach augmented reality lines up well with the principles of contextual learning theory and constructivism. Augmented reality (AR) allows for the overlay of virtual, synthetic 3D objects onto the real world, to augment the visual perception of a system or environment.

In 2006, Kerawalla, Luckin, and Seljeflot Woolard developed an augmented reality learning environment for teaching about the earth, sun, and moon and tried to explore the potential of Augmented reality (AR) for teaching primary school science. Foundation engaged 6–8-year-

old students in a series of scientific investigations of Newtonian force and motion including a set of augmented reality activities. Among others, research findings indicated an interesting result that, although students are afraid to take physics courses, they are interested in some of the physical phenomena in their daily life, especially when performing physics experiments. Based on these results, the researchers reasoned that most students like to make inquiries and try new activities, including doing experiments by themselves.

Research findings confirmed the positive effects of Augmented reality (AR) on students' motivation and engagement. Positive gains in students' responses to the affective survey also supported the above suggestion. Furthermore, teachers underlined that Augmented reality (AR) mobile technology encouraged independence and freed the teacher to act as a facilitator, thus suggesting that mobile Augmented reality (AR) can provide a powerful pedagogical tool that supports student-centered learning. Augmented reality (AR) encourages students to recognize non-obvious or unseen factors as significant factors in ecosystem dynamics. Moreover, it is time and again verified that the Augmented Reality (AR) experience encourages the students to actively process the acquired knowledge, therefore helping them develop a deeper understanding, discover gaps in the knowledge gained, and realize the potential for transfer of that knowledge in similar, real-world contexts.

Status of AR in Current Science Teaching

Currently, due to the absence of tools for the development of science-specific AR for learning, most AR experiences designed for teaching science are limited to QR code reading which, in turn, superimposes digital, relevant content on the image in focus. Yet, advanced programming skills would still be required to develop a solid science-related, interactive learning experience that implements specific learning goals. Such tools are necessary to allow the teacher herself/himself to organize and configure a learning experience concerning a particular learning subject and implement specific educational goals, as well as to create realistic 3D phenomena, and representation models. Furthermore, successful implementation of such an approach closely relates to the educator's ability to handle it and introduce it seamlessly into the school class.

Moreover, the development of appropriate AR learning experiences might further indicate specific abilities and skills that could be enhanced within appropriate augmented reality environments, such as cognition of dynamic processes and the ability to conceptualize phenomena that are impossible to observe in real-world surroundings. Emphasis should be

given to enhancing these experiences with scientific knowledge in such ways that learners are convinced of their faulty preconceptions and are, therefore, willing to give up their prior ideas and embrace scientific knowledge.

Application Of AR App in Teaching-Learning Process of Science

Many scientific phenomena are impossible to see. For example, the magnetic field cannot be observed directly, while other phenomena are unavailable because of the size, such as atoms or galaxies. Time may also be a dimension that limits the observation opportunity. Wu et al. (2013) emphasized that Augmented Reality (AR) systems can support learners in visualizing abstract science concepts or unobservable phenomena, specifically noting the following affordances:

• learning content in a 3D perspective
• Ubiquitous, collaborative, and situated learning
• learners' sense of presence, immediacy, and immersion
• Visualizing the invisible
• Bridging formal and informal learning.

Munnerley et al. (2012) likewise emphasized the opportunities for mobility, visualization, alternative perspectives, and comparison/contrast of multiple perspectives.

AR app in the perspectives of Students and Teachers

Students' use of multimedia when learning science, e.g. through making unseen processes visible, is also highlighted in the research literature about ICT in science education in general. Simulations and animations are in particular considered to support science learning if encourage what-if questions. An inquiry-based approach is highlighted as central when learning science, and AR technology positively supports students in the collection, organization, and analysis of data and the development of scientific explanations connected to this. Looking forward, they call for learning technology to be used by teachers to support students' situated inquiries in real-world contexts, referring to the five learning principles of active construction, situated learning, cognitive tools, reference to learning goals, and scaffolding to support students in completing challenging tasks. In the pertinent literature, there is a call for gaining greater knowledge about the educational use of AR being generated close to the educational context, including guidelines supporting teachers in promoting student learning.

Students, on the other hand, are one of the two main considerations in evaluating an educational technology, the other being the teachers. Their comfort with technology, access

to technology, and openness to change should be carefully reviewed. In that sense, there is a strong possibility that they are comfortable with Augmented Reality (AR) technology. In some schools, tablet-based instruction is at the center, which makes Augmented Reality (AR) technology more accessible. Through BYOD, it becomes more accessible to implement Augmented Reality (AR) technology. In that sense, there is a strong possibility that they are comfortable with Augmented Reality (AR) technology (Wang et al., 2017).

As teachers are the ones who are going to initiate Augmented Reality (AR) in their classes, their comfort, competence, openness to change, role, and classroom management issues should be considered. Teachers' competence in using this technology is crucial and this competence can be provided with professional development, which needs to be related to teachers' teaching context. In the curricula, there are learning goals to be met and educational tools should help work towards that. The cultural relevance of technology is also one of the things to be considered.

Conclusion

It is widely felt that the student activities in learning activities, quality of the learning process, and learning outcomes gradually enhanced at each stage of the cycle. Hence, it is believed that the adoption of Augmented Reality (AR) in science learning could improve interest, motivation and ultimately helps students to provide both conceptual and practical experiences in and around the subject of science. So far as the concept of the earth is concerned, visualization of the structures of the earth, volcanic events, tectonics, and the formation of various types of rocks happen on account of AR technology and makes it easier for the students to master the materials, connect between concepts in understanding other concepts, and apply them in analyzing and solving problems so that student learning outcomes in science learning become better. There are numerous Augmented Reality (AR) available which may be utilized in various subjects in general and science subject in particular. As this technology is not specifically developed for teaching-learning purposes, its integration into the activities and tasks requires a well-thought teacher touch. In the future, Augmented Reality (AR) along with VR, and MR, is likely to take their places in all parts of education. It is the time to be well acquainted with the emerging technology so that both students and teachers have an intense interaction with the technology. This familiarity can be a positive factor in the employment of Augmented Reality (AR) across the teaching-learning process and will be a significant key to opening the doors of education.

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