

## **Augmented Reality Application: Current status, opportunities, and challenges of Indonesian secondary education context.**

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### **ABSTRACT**

This article aims to investigate the studies about the implementation Augmented Reality (AR) in Education, particularly to have a closer look at the opportunities and challenges of AR application in Indonesian educational context. Finding of this study were analyzed through a synthesis research. The current empirical studies related to AR implementation in education were descriptively analyzed, and carefully synthesized. AR is one of the emerging technologies which has a big promise on teaching and learning. This study reveals that AR may offer a meaningful and engaging learning experiences because AR based learning can provide critical thinking activity with problem solving tasks. Furthermore, well-designed AR may situate a collaborative learning which can enhance students' positive behavior and attitude. However, this essay also reveals some limitations of AR application need to be taken into consideration, especially when it comes to technological and learning issues. Consequently, AR may not be the ideal solution for all learning settings, yet the ongoing development of AR technology on handheld mobile devices offers a big optimism for future learning. It is highly expected that the vast development of AR may positively influence learning and become more significant in the future.

**Keywords:** . Augmented Reality, Engagement, Learning

### **INTRODUCTION**

Given the era of the digital generation, UNESCO has widely questioned the goals of education in the 21<sup>st</sup> century. It is believed that the rapid change of technology development has gradually altered the way current generation perceives information (Dunleavy, Dede, & Mitchell, 2009). Students nowadays whom Prensky (2001) categorises as a digital native have a propensity to think in a different way because of continuous exposure to technology. They have become accustomed to using technology to deal with daily tasks which construct the way they learn and solve the problems (Prensky, 2001). However, students today are different, yet educational practices and learning materials provided are changing

very slowly. To cope with such change, schools must adapt actual students' needs by reidentifying learning strategy that can effectively engage such millennial generation. In other words, the concepts of learning, learners and educational digital technology itself must be fully understood in order to design a meaningful learning environment that address the students' learning preferences and needs (Selwyn, 2011).

Augmented Reality (AR) is widely seen as one of emerging technologies that can be employed in a wide range of learning settings. Many scholars believe that AR has big potentials to offer a meaningful and engaging learning environment. In this essay, therefore, the integration of AR technology into pedagogical practice would be critically examined. More precisely, this essay seeks to discuss how AR technology offers opportunities in learning and presents some challenges confronted during application. The overview of AR implementation in Indonesian secondary schools is firstly presented in this essay. It is further followed by the discussion of AR affordances and limitations need to be taken into consideration when implementing such sophisticated technology. The conclusion would highlight the main points of the investigation and provide future research recommendation. In addition, as stated earlier that the essay would criticise the possible implementation of AR technology in relation Indonesian secondary schools, three important issues would be carefully investigated. AR technology could enhance the learning experience by engaging students' emotion, cognition and behaviour

## **METHOD**

This study used synthesis research in which the current studies that discuss the notion of AR in education context are descriptively analyzed, synthesized and integrated. Onwuegbuzie, Leach, & Coolins (2011) stated that this method is carried out by synthesizing empirical studies to draw conclusions. In this study, the studies surrounding the issues of AR application in Education were taken from three main sources which are google scholar, ERIC journal and Scopus. To find the relevant studies, specific keywords related to Augmented Reality, Education, Indonesia, Learning Engagement, were employed. In addition, the search of relevant studies also implemented the aid of Boolean operators such as AND, OR, and NOT to limit and specify the focus the search. After the studies listed, they then manually checked and carefully selected to be the final list of relevant studies being reviewed.

## **RESULTS AND DISCUSSION**

### ***An Overview of Augmented Reality Implementation in Indonesia***

In order to know the current issue of augmented reality integration into pedagogical practice in Indonesian high schools, it is better to have a better understanding of the educational policy of digital technology implementation in Indonesia. In this part, therefore, the issues of educational policy transformation

towards the use of digital technology and the actual development of AR Indonesian high school level would be separately discussed in the following paragraphs.

The Indonesian government has paid much attention to the issue of integration of digital technology into the classroom. It can be seen from the educational policy being issued during recent years. In 2013, the ministry of education made an educational policy to abolish ICT subject on curriculum 2013 (K-13) at secondary school level (Mattarima & Hamdan, 2016). Tough receiving some critics, yet the idea behind this controversial regulation has been widely appreciated by many educational practitioners in Indonesia. One of the primary reasons is that the benefits of educational digital technology cannot be effectively gained through learning if digital technology is solely merged as a subject. Rather, digital technology should be entirely integrated as a pedagogical concept into all learning environments. It is intertwined with what Selwyn (2011) views that educational technology is not merely a tool of learning being taught in a classroom but it should be inherently conceptualised as a means of artefacts, activities and contexts embedded in every educational activity.

To achieve the desired objectives, the national government has invested more funding on the educational sector at least 20 percent from national expenditure (Indonesia, 2003). Given such privileged budget allocation, stakeholders are highly expected to reform education system following the updates of dynamic changes of the digital world, preparing technology-proficient teachers to deal with the demands of 21<sup>st</sup>-century learning. In this light, another transformative policy to ensure the implementation of digital technology in schools is by issuing the Ministerial Regulations Number 16 of 2007, Number 41 of 2007 and Number 16 of 2017 (Kemdikbud, 2018). Those regulations implicitly state that one of the teachers' competences is having the ability to incorporate digital technology into their teaching strategy in the classroom. In other words, with this national regulation, educators are obligated to always upgrade their proficiency and become technologically competent to use a various range of educational technologies in the classroom. For national government, the transformation of learning from the traditional approach to digital learning is believed as one of the ways to enhance the quality of education in Indonesian secondary school level. It is argued that technology-based learning offers an exciting opportunity to design fun, realistic, authentic and engaging learning environments (Kirkley & Kirkley, 2004). In addition, scholar also highlighted that technology has a big promise for fostering learning engagement and learning content understanding (Wu, Lee, Chang, & Liang, 2013). Those are essential factors that drive to the better academic result (Prensky, 2001).

One of the emerging technologies, which would be discussed throughout this paper, is Augmented Reality (AR). AR technology is seen promising to have potential and impact on teaching and learning. AR is defined by many scholars as a

system that allows people to interactively experience virtual object that is intrinsically embedded within the physical world (Azuma, 1997). In other words, AR can be referred as a form of virtual environment where the virtual elements, such as 3D images, voices, videos, and graphics, are superimposed or overlaid onto the real world to enhance visual experience, increase visual system and assist the users to attain their task in more meaningful and natural way (Antonioli, Blake, & Sparks, 2014). AR can work in several ways by using certain devices like head-mounted displays, handheld devices, eyeglasses, contact eyes, monitor and gaming consoles (Antonioli et al., 2014). According to Dunleavy et al. (2009), two forms of AR are potentially available for teaching and learning, which are location-aware AR and vision-based AR. The former enables learners to pass through a physical environment with GPS-enabled handheld devices such as smartphones, tablets, or similar mobile devices. The latter overlays 3D digital media to students after pointing the camera of their smartphone at an object with QR code or 2D target. As a result, the versatility provided by AR technology allows the development of its implementation for a wide range of learning classrooms such as geography, physics, mathematics, language, sports (Bujak et al., 2013; Liu & Tsai, 2013; Wojciechowski & Cellary, 2013). In terms of instructional learning approach, AR can be potentially employed in various ways like game-based learning, place-based learning, participatory simulations, problem-based learning, role-playing, studio-based pedagogy, and jigsaw method (Wu et al., 2013).

In Indonesia, even though AR has gained much attention since Pokemon Go game became popular in 2016, but only a few scholars have attempted to explore the potential of AR integration for educational purpose. Irwansyah, Yusuf, Farida, and Ramdhani (2018) carried out a design-based research to explore the feasibility of the use of AR apps on the android system in chemistry. They further developed an AR apps as a technology-based media to teach molecular geometry concept. The result implies that AR media on the android system can be potentially employed on chemistry classroom, mainly for a molecular geometry lesson. Another study undertaken by Pendit, Zaibon, and Bakar (2014) developed a so-called *AR@Prambanan* to provide enjoyable informal learning experience at cultural heritage site of Prambanan Temple, Yogyakarta, Indonesia. It is basically a mobile AR application which was designed based on three major theories namely design of enjoyable technology, enjoyment theory and mindfulness theory. The finding further reveals that the respondents who had tried *AR@Prambanan* responded positively toward the implementation of such AR application at the cultural heritage site. The similar finding is also affirmed by Setiawan, Kartikadarma, and Haryanto (2013) who integrated a traditional game called Gobak Sodor into ARGASIN game. It is an AR computer simulation game which can be played in two teams. The study argues that though the game is still lacking in interactivity and designing, the majority of students in their study have a positive attitude, high

interest and curiosity in playing a traditional Gobak sodor game using ARGASIN game platform.

To conclude, this part has attempted to explore a brief summary of the regulations in Indonesia towards the implementation of digital technology in Indonesia and the surface of AR development in secondary school level. It can be argued that Indonesian government seems to believe that deep reform of education is needed. The shift to a more self-directed learning under the framework of technology-based learning is viewed to be effective to lead to a more sustained learning across the national curriculum. In this sense, AR is seen to have a big promise to be employed as one of the emerging technologies in many various learning contexts. Therefore, the opportunities and challenges of integrating AR technology would be briefly discussed throughout the following section.

### ***The Opportunities and Challenges of AR Integration***

Having a better understanding of the issue above, we can move forward in analysing how AR technology offers opportunities in learning. Moreover, as mentioned earlier, this section would discuss the possible affordances of AR application on teaching and learning in relation to Indonesia secondary school context. Three opportunities of AR would be examined followed by the discussion of its limitations need to be taken into consideration.

AR Technology is seen as a pedagogical tool that offers a big promise to the enhancement of learning engagement in a wide range of learning environments. The assertion that AR- based learning can nurture students' engagement is grounded in the lens of situated- learning theory (Dunleavy et al., 2009). The theory of situated learning was coined by Lave and Etienne Wenger (1990) who argue that students are more likely to learn by getting involved in the learning process in contrast with listening to the teacher in classrooms. As opposite with conventional learning activities which emphasise on the transmission of abstract knowledge, Lave (1991) believes that learning should be situated and embedded within activities, cultures, and contexts. He further highlights that learning activity should be unintentional instead of deliberate. This idea refers to the process of legitimate peripheral participation (Lave & Wenger, 1990). In addition to this, knowledge should be normally delivered in authentic learning environments where students actively get immersed in problem solving activity. Situated learning also involves students in collaborative activities. Under this situation, learners can learn based on their learning preferences as situated- learning environments provide various learning activities. In this regard, a social community that replicates real-world context plays a significant role. That is why the quality of learning is relying on the interactions amongst individuals, objects, places, cultures and learning process itself (Woolfolk & Margaretts, 2016). Vygotsky echoes the same idea in his sociocultural theory that social interactions amongst learners within the learning

context acts as a salient aspect to enhance learning experiences (Woolfolk & Margaretts, 2016).

Scholars have highlighted that AR technology has great potentials to flourish engagement under the framework of situated-learning theory (Dunleavy et al., 2009). The term of engagement is defined as the level of curiosity, attention and interest whilst getting involved in the learning process (Fredricks, Blumenfeld, & Paris, 2004). Fredricks et al. (2004) further suggest that engagement can lead to positive learning outcomes while participating in a learning activity that involves cognitive, emotional and behavioural engagement. Cognitive engagement refers to learning reflection which drives to critical thinking activity. Emotional engagement relates to emotional reactions to the learning activities such as interest, excitement and enjoyment. Behavioural engagement relates to putting effort into learning tasks such participation and involvement (Fredricks et al., 2004). In some circumstances, those three kinds of engagement could be potentially driven by AR-based learning environments.

### ***Emotional Engagement***

AR technology is seen to have a big potential to engage students' positive emotion towards the learning activities. It is because a classroom under the framework of AR-based learning offers meaningful and enjoyable learning activities for students. In this sense, AR technology allows students to visualise 3D objects in a simulated way, different angles and real-time (Wu et al., 2013). This assists to make learning environments more circumstantial and authentic (Antonioli et al., 2014). As a result, students could feel excited and entertained while learning. A virtual world offered by AR technology also encourages students to think imaginatively and discover new information in a fun and interactive way (Wu et al., 2013). This interaction may enhance learning and support to retain information for a longer time (Antonioli et al., 2014). Another factor is that students could encounter a sense of immersion in an imaginative environment as they positively enjoy virtual object embedded within the physical world. A study conducted by Donald (2016) supports these ideas. The results both observation and students' feedback after learning through a so-called *Mission not really impossible* (AR Game) indicate that students are enjoyably engaged in learning. Being immersed in AR environment is the main reason why the students have such positive attitude (Donald, 2016).

In addition, the students may experience being in the flow condition if AR is successfully aligned into a more meaningful way (Kye & Kim, 2008). The idea of flow was originally coined by Csikszentmihalyi (1997). It relates to being enjoyably engaged and concentrated on performing a certain activity (Csikszentmihalyi, 1997). This is a condition in which individual encounters a high experience of complete absorption. AR technology, therefore, is viewed to have such potential to bring students in the state of flow. Kye and Kim (2008) undertook a study to

investigate which AR factors can enhance learning. The study further reveals that immersion, manipulation and presence offered by AR technology are three main factors that drive the students to the flow zone, which positively leverage learning effects like satisfaction, understanding knowledge, excitement (Kye & Kim, 2008).

Nevertheless, under some circumstances, AR implementation on learning might be fragile. Some studies point out that instead of enhancing emotional engagement, technical issues in utilising AR technology may disengage students in learning. For instance, a study conducted by Hsu and Huang (2011) shows that even though the majority of students considered AR devices are easy to operate, but most of them felt the AR devices are not effective in reading textbooks. They found their selves frustrated at obtaining information. Due to internet connection issue, students needed to wait for a more time just for accessing or sending images, recognising or getting the meaning of the text displayed on the screen (Hsu & Huang, 2011). The similar issue also might be widely found in Indonesia. Tough Indonesia is categorised as one the growing countries for internet usage, yet the average internet connection still lags far behind compared to selected Asia Pacific countries, which is only 7.2 Mbps (The Statistics Portal, 2017). As a result, it would be problematic to integrate AR technology in Indonesian school since it highly relies on speed internet connectivity.

The challenge mentioned above mostly relates to the technical problem of utilising AR during the learning activity. Such technical issue may be solved in the future since the rapid development of technology including internet connection in Indonesia is an ongoing process. The improvement of internet portability is paramount in order to facilitate students to access AR system via smartphone or tablet (Dunleavy et al., 2009). Such mobile handheld has been seen to have the potential to make AR more meaningful pedagogical tool which enables students to absorb knowledge and enhance positive emotion through their interactions with mobile AR environments.

### ***Cognitive Engagement***

Scholars also consider that AR technology could be a pedagogical practice to engage students' cognition by fostering critical thinking in the learning activity. Elder and Paul (1994) define critical thinking as a capability of individuals to control their thinking and expand relevant standards for analysing and assessing their own thought. This process is required to overcome any problems individuals may have. Schrier (2007) conducted a study to examine whether AR game called *Reliving the Revolution (RtR)* leverage students' critical thinking in history class. It is basically a location-based AR game that can be played with handheld mobile devices such as mobile phone and tablet. The study further concludes that AR game offers some main factors to enhance critical thinking skill. The main factor is that AR game environments situate interpretive, collaborative and problem-solving

activities need to be solved by the students. The students are put into a deeper cognitive engagement because they are encouraged to be involved critically in the problem-solving challenges. Consequently, the students are situated to become a decision maker, exploring their own thought and figuring out their abilities to solve the game challenges.

Another study undertaken by Bower et al. (2014) also supports the idea that AR technology may engage students in a higher order thinking activity. This is because AR technology enables students to create their own augmented images. Certain AR platforms like Blippar, Aurasma and Augment allow students to design 3D objects. Bower et al. (2014) carried out a case study and situated their respondents in learning by design activity in order to make augmented objects based on the learning objectives. After analysing students' works and their feedback, the study further concludes that AR-based learning can lead students to a high level of creativity, independent thinking and critical analysis. For this reason, most students have a positive attitude learning under the framework of AR design-based learning because they could experience new things by creating 3D images and explore their own idea. This leads them to think out of the box and make their own choice instead of pre-set choices.

Regardless the benefit of AR that can foster critical thinking, the usability and complexity of tasks, on the other hand, may result in cognitive overload during learning. Some studies have pointed out the issue. Dunleavy et al. (2009) highlight in their finding that respondents often got confused and overwhelmed when they involved in AR simulation environment as they needed to cope with the unfamiliar technology devices and complex learning tasks. The study further suggests that to maximise the learning outcomes, students should be multitasking because AR environment might involve students to use multiple skills such as technology manipulation, problem, teamwork, spatial navigation and mathematical estimation (Dunleavy et al., 2009). In addition, Cognitive learning theory highlights an important issue that cognitive overload which is detrimental to learning outcome could be caused by a free exploration of complex learning tasks (Paas, Renkl, & Sweller, 2003), particular important for younger learners and novices at involving in open-ended investigations with insufficient prior knowledge to deal with AR environment (Dunleavy et al., 2009). The case may make students cognitively overloaded because they have to operate multiple technological AR devices, absorb a large amount of information and accomplish complex tasks provided (Wu et al., 2013).

### ***Behavioural Engagement.***

In addition to emotional and behavioural engagement, AR technology can situate collaborative learning which can engage students' behaviour during the learning activity. Collaborative learning is broadly defined as a learning activity in

which two or more learners work or learn synergistically to attain shared goals (Johnson, Johnson, & Smith, 1998). In the AR learning environments where the virtual embedded within the physical worlds, learners can learn while interacting with other learners in the same space (Phon, Ali, & Halim, 2014). This condition naturally drives to collaborative engagement (Park, Jung, & You, 2015). Under this situation, A designed AR environment enables students to experience a sense of togetherness being involved in the collaborative activity, showing social life skills like contributing, encouraging, sharing and persuading with one another. Those skills are in line with the principles of collaborative learning which are expressing interpersonal interaction and positive interdependence (Johnson et al., 1998). To support this argument, Alem, Furio, Juan, and Ashworth (2011) carried out a study to examine whether or not an AR mobile game called *Greenet* can affect students' attitude and behaviour. Students were situated in small groups to collaboratively deal with the learning tasks. The study further argues that collaboration under the framework of AR Game-based learning positively changes students' attitude and behaviour especially for persuasion and encouraging skills (Alem et al., 2011).

AR technology on mobile devices is seen unique because it can offer collaborative learning both of physical and virtual interaction. (Lukosch, Billingham, Alem, & Kiyokawa, 2015). For instance, vision-based AR provides a natural setting to enhance face to face interaction amongst learners and teacher (Kaufmann, 2003). The main benefit of utilising AR in collaborative activity is that learners in a group can see and interact with three-dimensional objects while discussing to other group mates. Dunleavy et al. (2009) reveal the same result that immersive hybrid learning environments offered by AR technology can flourish the enhancement of interdependent collaborative activities. The combination of digital and physical world is the most engaging feature for learners to be involved in collaborative tasks. In addition, the more omnipresent and portable handheld mobile devices today can also support AR interaction either physical or virtual environment in the more interactive, immediate and convenient way (Phon et al., 2014). AR Apps can be mostly run on any mobile phone or tablet. They are ubiquitous and have the basic hardware to utilise AR such as motion sensors, cameras, processors, screens, and internet connectivity (Lukosch et al., 2015).

Even though AR technology is seen mature enough to promote collaborative learning, yet there still some major issues need to be taken into account, especially when it comes to the technological issues in integrating AR technology into the collaborative learning environment. Certain devices to run AR such as a head-mounted display equipped with additional computer device are cumbersome and expensive. To some extent, it would cause discomfort and depth perception (Antonioli et al., 2014). Although current AR system can be utilised on portable devices which are less obtrusive and can improve a sense of presence and immersion. But, the system should be combined with several software and

hardware devices. These may lead to another issue such as instability of the devices and interfacing with multiple devices (Dunleavy et al., 2009). Therefore, the more the AR devices are utilised, the more the risk of device errors. In collaborative AR activity, maintaining the stability of multiple devices becomes critical. For example, a study undertaken by Dunleavy et al. (2009) argues that internet, GPS errors and unstable AR apps are problematic issues which could cause students' frustration. These issues may be actually solved by the ongoing advanced development of such technology. Thus, it is highly expected that portable mobile devices in AR technology would be more reliable and integrated when running GPS, games, simulation and video.

## CONCLUSION

To conclude, AR technology offers some opportunities to be integrated into a wide range of learning environments in relation to Indonesia secondary school setting. Because of its versatility, AR technology may provide a meaningful and engaging learning activity. Also, AR technology plays a salient role to enhance learning experiences which engage students in critical thinking activity dealing with problem-solving tasks. In addition, well-designed AR may situate a collaborative learning which can enhance students' positive behaviour and attitude. However, this essay also reveals some limitations of AR application need to be taken into consideration, especially when it comes to technological and learning issues. Consequently, AR may not be the ideal solution for all learning settings, yet the ongoing development of AR technology on handheld mobile devices offers a big optimism for future learning. It is highly expected that the vast development of AR may positively influence learning and become more significant in the future.

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