Impact of using augmented reality applications in the educational environment

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Abstract. This study discusses a literature review that focuses on the use of Augmented Reality in the educational environment. The author reviews articles published in the last 10 years that discuss the use of Augmented Reality in learning media at all levels of education. A total of 30 articles were analyzed thoroughly. The result shows various types of research methods were found and the levels of education varied from early childhood education, elementary school, junior high school, senior high school, vocational school, and tertiary education, even the technology was also used for students with special needs (disability). The research designs found also varied such as Experiment, Analysis, Action Research, Surveys, Mixed Method, and Research-Based and Development. The most prominent role of Augmented Reality in educational environment is to increase students’ thinking ability, understanding, motivation, response, and learning outcomes towards the learning process. Most of the researches were conducted in secondary level while little attention was given in vocational level. Thus, this article would recommend to future studies to conduct more researches in vocational setting in order to display more evidence about the phenomenon of Augmented Reality in educational setting.

1. Introduction
In the implementation of education, educational institutions must facilitate the learning process in accordance with the characteristics of the students by offering the use of technology as a media that supports the interaction of students and teachers [1][2][3]. Students often feel that they are not directly involved in the learning process because the use of learning media are less effective [4][5]. Integrating the latest technology in the learning environment will have a positive impact on the development of knowledge and also influence the students’ enthusiasm emotionally which affect the improvement of the students’ quality learning [6][7][8].

The use of instructional media that is less interactive and less students’ involvement in the learning process cause students do not understand the material conveyed by the teacher [9]. For this reason, it is necessary to have an interactive media learning space that aims to prepare all students to gain successful experience in formal and informal education. Moreover, with the development of new digital media which is an opportunity and a new challenge in the world of education today, the integration of media in a teaching-learning situation is needed, especially in designing interactive learning that supports the learning process [10][11].

At present, there are many learning methods that are developing, however some teachers still use conventional learning which is a bank-style learning method where the teacher is the only conveyor of information that could be used and remembered by students [4]. If a student uses their information and
communication technology in learning, they can interact and be active with each other in the learning process [12][13]. Therefore, a good solution is needed so that every material can be delivered well and interesting to students.

Progress in the field of technology has changed people's lifestyle habits much as many young people are free from the digital world of mobile devices that help them in the learning process and learning environments in a formal, non-formal, and informal manner [14][15][16]. The rapid recovery of multimedia technology during the past decade has brought about major changes and all of them have experienced an improvement from the aspect of the technology itself as well as aspects of the field of science so that it greatly benefits the development of the world of education [5][17][18].

Especially in vocational education, the development of Android-based Augmented Reality applications is expected to be a solution in learning media problem. Augmented Reality is a technological application that combines virtual objects into the real world both in two-dimensional and three-dimensional forms. This merger is then maximized by the ability to interact directly with these objects so that they become a practical choice of learning media in the last few years [14][18]. Technological developments give rise to new, practical and innovative ideas in developing interactive learning media and become one of the most promising technological applications that can be used in school-learning processes and as an alternative in developing students' academic abilities [18][19][20].

In this article, we will discuss the literature review on the use of Augmented Reality in the world of education, which refers to segments of the impact of Augmented Reality technology on the educational environment that can be used as a reference in research. The results of the review were identified and analyzed and conclusions were made. In the last section, it is also explained about the trends in the use of Augmented Reality in the educational environment as well as opportunities for Augmented Reality research in the future.

2. Augmented reality

Augmented Reality (henceforth AR) is a technology application that combines virtual objects into the real world both in two-dimensional and three-dimensional forms. This merger is maximized by the ability to interact directly with these objects so that they become the choice of learning media in the past few years [11][18][21]. Augmented Reality (AR) technology was implemented in the 1960s and gradually developed at the Boeing company in the early 1990s [16][22]. Augmented Reality is a fairly clever concept because students use imagination in the learning process.

There are 3 main characteristics possessed by AR, namely; a). a virtual combination in the real world, b). creating an interactive atmosphere in real time and c). aligning real objects with virtual objects [23][24]. The presence features possessed by AR can help students playing an active role in the learning process [24][25]. where the development of technology can help students learn independently and add their own experience even with limitations of facilities and design of relevant teaching materials at present [26][27][28].

3. Method

3.1. Data collection

The steps taken in the review literature were done by searching the collection of journals on electronic database pages such as Emerald, ScienceDirect, and Sage on Google Scholar services, followed by Scopus by typing keywords on web pages "Learning Media and Augmented Reality (AR) or augmented reality android based or Learning Media Using the Android-Based Augmented Reality (AR) Application. A total of 30 articles had been collected about Augmented reality technology in the last 10 years with time span from 2009 to 2018. Then the collected articles were read, analyzed and reviewed by coding the data through the subject of each article in the spreadsheet program. The review aimed to examine the latest literature regarding the use of Android-based augmented reality applications in learning.
The electronic databases used to find the articles were including Springer Science + Business Media, ELSEVIER, CrossMark, IEEE (Institute of Electrical and Electronics Engineers), Hindawi Publishing Corporation, ASE (Anatomical Sciences Education), British Journal of Educational Technology, SAGE, and Taylor & Francis Group. The code used in the study was arranged based on the following sequence: (1) Study: which contains the title, author and time of the study, (2) Participant: which covers the research sample, (3) Context of the data: the article/journal publication date, (4) Type of data: which involving the techniques/methods used in research as well as, (5) Basic Findings: which talks about the conclusions and results of the article. After reviewing, the articles were then analyzed based on the general conclusion in order to shed a light upon the recent development of the utility of AR in educational setting especially in the learning process and to display an opportunity of AR in the future.

Table 1. Format log book jurnal review.

| Study          | Participation | Contact Data | Type of Data | Basic Fundings                                                                 |
|----------------|---------------|--------------|--------------|-------------------------------------------------------------------------------|
| Hsiao et al. [16] | This study focuses on how to increase interactivity and the benefits of AR by integrating interactive tools of manipulation in the real world. The study sample was 64 class VI students aged 12-13 years in the city of Taipei | 13 July 2013 | Experiment | 1. MAR system offers effective learning in learning.                           |
|                |               |              |              | 2. Manipulative assistance learning tools have an effective impact on the interactivity and benefits of AR. |

| Castillo et al. [1] | In this study, a sample of 59 students was taken in Mexico University | 12 January 2015 | Experiment and interview | 1. There was an increase in learning outcomes for the experimental group, the average value was higher than the control group. |
|                    |               |              |              | 2. From the results of the interview, it can be concluded that the positive response from students towards the use of Technology to support the future learning process. |
Table 1. Cont.

| Cai et al. [20] | Title: Applications of augmented reality-based natural interactive learning in magnetic field instruction | The sample of this study was 42 students in class VIII which were divided into 2 class groups, namely the control class and the experimental class. | Augmented Reality sensing software can increase the interest and results of student learning especially in learning Physics magnet field motion material. |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
|                 | 24 May 2016 Experiment | 2016                                                                                                                              | 2. Overall both lecturers and students who were research samples agreed to say that learning by using the augmented reality application provides a new positive experience. |
| Kelly et al. [11] | Title: Augmented Reality Learning Environment For PhysioTherapy Education | A total of 9 students from the University of Melbourne majoring in Physiotherapy from all levels were taken randomly consisting of 3 men and 6 women, and 3 lecturers who participated in the evaluation. | 1. From the results, it can be concluded that Physiotherapy learning by using environment-based augmented reality technology received positive responses both in terms of student satisfaction, as well as understanding the provided material. |
| 20 March 2018 | Questionnaire / Observation and Interview | 2018                                                                                                                              | 2. Overall both lecturers and students who were research samples agreed to say that learning by using the augmented reality application provides a new positive experience. |

3.2. Review article

The selection of the articles must have the following criteria: a) Related articles are providing the use of AR technology in the educational environment, b) Articles must be published within the last 10 years. The result of the article reviewed based on the year of publication is displayed in Fig. 1.

![Figure 1. Chart published articles viewed from the year of publication.](image-url)
3.3. Data analysis
A total of 30 articles analyzed in this study had fulfilled the criteria for the initial inclusion that the influence of augmented reality implementation as learning media can significantly affect students’ motivation and learning outcomes, especially in the last 10 years.

3.4. Category of AR
The main category chosen in this study was the use of Augmented Reality (AR) technology in the world of education. Augmented Reality (AR) was developed specifically aimed at its use as learning media in learning process.

4. Results

4.1. General findings
Based on 30 articles reviewed in this study, the use of augmented reality in learning activities which involves various methods, it was found that the development of learning media using augmented reality technology with different models was conducted in a varied education levels such as early childhood and elementary [6][25][26][28], junior high [20][29], senior high [12][16][22][30][31], vocational school [19], college setting [1][9][17][32], and the development of Augmented Reality was also found in a special setting such as children with special needs (disability) [18][14]. The result of the journals review can be seen in Fig. 2.

![Figure 2. Use of Augmented Reality applications from the level of education.](image)

4.2. Special findings

4.2.1. Students’ response on the use of AR technology in the learning process. The implementation of the development of Augmented reality technology raises a very positive response from students. The students feel satisfied and motivated towards the use of AR technology in the education field[22][32][33]. In addition, educators, both teachers and lecturers, have a positive impression towards the use of AR technology in educational environments [11], where users can improve their experience in the teaching and learning process [10].
4.2.2. **The impact of using AR technology on the learning process.** The findings show that the implementation of AR serves some advantages in the learning process where it shows an improvement not only on learners’ cognitive skill [10][15][28][34] but also it generates students’ motivation which affects their achievement in the learning process [8].

4.2.3. **The development of AR in vocational field.** AR has its significant role as an app and teaching media in the educational field [35], the reason is taken from the evidence shown in the articles analyzed in this study that AR can positively affects and improves learners’ thinking skill by looking at its significance improvement on the cognitive, affective, and psychomotor aspects[20].

5. **Conclusion**

Augmented Reality (AR) is a sophisticated technology that transforms some virtual objects into two or three dimensions. The transformation is then developed in order to make it as real as people can directly interact with it. Therefore, in recent years, it becomes worth applying as a teaching media. AR provides useful features that help learners to be active in terms of it supports learners’ to become independent learners and their experiences.

This is a review of some studies regarding AR role in educational field that is published by: Springer Science+Business Media, ELSEVIER Publishing, CrossMark, IEEE (Institute of Electrical and Electronics Engineers), Hindawi Publishing Corporation, ASE (Anatomical Sciences Education), British Journal of Educational Technology, SAGE, and Taylor & Francis Group. Various data collection were used in these articles such as questionnaire, interview, observation, and pre- and post-test which make this study able to clarify what has been going on in the circle of AR implementation. Thirty articles related to AR implementation on the educational field were selected, and it explores cognitive, affective, and psychomotor aspects that include learners’ thinking ability, understandings, motivations, responses, and outcomes towards any learning materials. Those thirty articles were mostly aimed at senior high school field with one article only aimed at the vocational high school. Overall, the use of Augmented Reality technology creates a positive impression on the learning environment and the learning process at all levels of education.

**References**

[1] Barraza Castillo R I, Cruz Sánchez V G and Vergara Villegas O O 2015 A pilot study on the Use of mobile augmented reality for interactive experimentation in quadratic equations Math. Probl. Eng. 2015

[2] Kurilovas E, Kubilinskiene S and Dagiene V 2014 Computers in Human Behavior Web 3 . 0 – Based personalisation of learning objects in virtual learning environments Comput. Human Behav. 30 654–62

[3] Violante M G and Vezzetti E 2015 Virtual interactive E-learning application: An evaluation of the student satisfaction Comput. Appl. Eng. Educ. 23 72–91

[4] Tobar-Muñoz H, Baldiris S and Fabregat R 2017 Augmented Reality Game-Based Learning: Enriching Students’ Experience During Reading Comprehension Activities J. Educ. Comput. Res. 55 901–36

[5] Maksudi H, Wiharna O and Rohendi D 2016 Pengaruh Penggunaan Multimedia Animasi Pada Pembelajaran Kompetensi Dasar Memperbaiki Sistem Starter Terhadap Peningkatan Hasil Belajar Siswa Smk J. Mech. Eng. Educ. 3 174–82

[6] Yilmaz R M 2016 Computers in Human Behavior Educational magic toys developed with augmented reality technology for early childhood education Comput. Human Behav. 54 240–8

[7] Osman K and Lee T T 2014 Impact of Interactive Multimedia Module With Pedagogical Agents on Students’ Understanding and Motivation in the Learning of Electrochemistry Int. J. Sci. Math. Educ. 12 395–421
[8] Huang T C, Chen C C and Chou Y W 2016 Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment Comput. Educ. 96 72–82
[9] Lau N, Oxley A and Nayan M Y 2012 An augmented reality tool to aid understanding of protein loop configuration 2012 Int. Conf. Comput. Inf. Sci. ICCIS 2012 - A Conf. World Eng. Sci. Technol. Congr. ESTCON 2012 - Conf. Proc. I 500–5
[10] Moedjiono S, Nurcahyadi and Kusdaryono A 2018 Media Interactive Learning and biology subjects implementation with augmented reality application Proc. 2nd Int. Conf. Informatics Comput. ICIC 2017 2018–Janua 1–6
[11] Kelly D, Hoang T N, Reinoso M, Joukhadar Z, Clements T and Vetere F 2018 Augmented reality learning environment for physiotherapy education Phys. Ther. Rev. 23 21–8
[12] Dunleavy M, Dedé C and Mitchell R 2009 Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning J. Sci. Educ. Technol. 18 7–22
[13] Al-Said K M 2015 Students’ perceptions of edmodo and mobile learning and their real barriers towards them Turkish Online J. Educ. Technol. 14 167–80
[14] Smith C C, Cihak D F, Kim B, McMahon D D and Wright R 2017 Examining Augmented Reality to Improve Navigation Skills in Postsecondary Students With Intellectual Disability J. Spec. Educ. Technol. 32 3–11
[15] Turan Z, Meral E and Sahin I F 2018 The impact of mobile augmented reality in geography education: achievements, cognitive loads and views of university students J. Geogr. High. Educ. 42 427–41
[16] Hsiao K F, Chen N S and Huang S Y 2012 Learning while exercising for science education in augmented reality among adolescents Interact. Learn. Environ. 20 331–49
[17] Küçük S, Kapakin S and Göktas Y 2016 Learning anatomy via mobile augmented reality: Effects on achievement and cognitive load Anat. Sci. Educ. 9 411–21
[18] McMahon D, Cihak D F and Wright R 2015 Augmented reality as a navigation tool to employment opportunities for postsecondary education students with intellectual disabilities and Autism J. Res. Technol. Educ. 47 157–72
[19] Cubillo J, Martin S, Castro M and Boticki I 2015 Preparing augmented reality learning content should be easy: UNED ARLE - An authoring tool for augmented reality learning environments Comput. Appl. Eng. Educ. 23 778–89
[20] Cai S, Chiang F K, Sun Y, Lin C and Lee J J 2017 Applications of augmented reality-based natural interactive learning in magnetic field instruction Interact. Learn. Environ. 25 778–91
[21] Adhikari J, Mathrani A and Scogings C 2016 Bring Your Own Devices classroom: Exploring the issue of digital divide in the teaching and learning contexts Interact. Technol. Smart Educ. 13 323–43
[22] El Sayed N A M, Zayed H H and Sharawy M I 2011 ARSC: Augmented reality student card Comput. Sci. Educ. 56 1045–61
[23] Chang K, Chang C, Hou H, Sung Y, Chao H and Lee C 2014 Computers & Education Development and behavioral pattern analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum Comput. Educ. 71 185–97
[24] Pektas H M 2016 Computers in Human Behavior Augmented reality in science laboratories : The effects of augmented reality on university students ’ laboratory skills and attitudes toward science laboratories 57 334–42
[25] Cheng K and Tsai C 2016 The interaction of child–parent shared reading with an augmented reality (AR) picture book and parents’ conceptions of AR learning 47 203–22
[26] Chiang T H C, Yang S J H and Hwang G 2014 Computers & Education Students ’ online interactive patterns in augmented reality-based inquiry activities Comput. Educ. 78 97–108
[27] Wei X, Weng D, Liu Y and Wang Y 2015 Teaching based on augmented reality for a technical creative design course Comput. Educ. 81 221–34
[28] Cheng K H and Tsai C C 2014 Children and parents’ reading of an augmented reality picture book: Analyses of behavioral patterns and cognitive attainment Comput. Educ. 72 302–12
[29] Hsiao H S, Chang C S, Lin C Y and Wang Y Z 2016 Weather observers: a manipulative augmented reality system for weather simulations at home, in the classroom, and at a museum Interact. Learn. Environ. 24 205–23

[30] Kamarainen A M, Metcalf S, Grotzer T, Browne A, Mazzuca D, Tutwiler M S and Dede C 2013 EcoMOBILE: Integrating augmented reality and probeware with environmental education field trips Comput. Educ. 68 545–56

[31] Cuendet S, Bonnard Q, Do-Lenh S and Dillenbourg P 2013 Designing augmented reality for the classroom Comput. Educ. 68 557–69

[32] Dong S, Behzadan A H, Chen F and Kamat V R 2013 Collaborative visualization of engineering processes using tabletop augmented reality Adv. Eng. Softw. 55 45–55

[33] Chang H Y, Wu H K and Hsu Y S 2013 Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue Br. J. Educ. Technol. 44 95–9

[34] Chang Y J, Kang Y S and Liu F L 2014 A computer-based interactive game to train persons with cognitive impairments to perform recycling tasks independently Res. Dev. Disabil. 35 3672–7

[35] Bower M, Howe C, McCredie N, Robinson A and Grover D 2014 Augmented Reality in education - cases, places and potentials EMI. Educ. Media Int. 51 1–15