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Augmented Reality Based on Learning Assessment
A Scoping Review 2011-2020

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ABSTRACT
Augmented Reality (AR) is the development of a new era of technology that visualizes virtual objects (2D) to reality (3D). The application of this technology in various aspects of life, including education. There have been many studies on the application of AR in learning media innovations, so the goal of identifying AR-based learning assessment studies. The research method used is a scoping study. The results of data collection after being reduced based on the criteria used were obtained 6 articles from 36 articles. The analysis of the selected articles shows that the use of AR in learning has positive impacts on the dependent variables and suggests further research. The positive impacts that occur like better scoring for motivation, the usefulness of AR in learning, autonomous work, and students' 3D comprehension task.

Keywords: *Augmented reality, Assessment, Augmented reality-based assessment, Scoping study*

1. INTRODUCTION

The world of the 21st Century is filled with data and its rapid growth at an astonishing rate and collected to improve decision making about several aspects of life. The future trend is increasingly blurring boundaries between the real and virtual world [1]. 21st-century education is related to globalization and internationalization. Teachers are required to understand technology effectively to teach generation Z students [2]. 21st-century learning reforms education that is more suitable for the next generation to face the challenges of globalization posed by problems of equality, social justice, and environmental degradation [3]. Prerequisite for ICT resources as an education system that must be equipped with both hardware and software, and a collaborative learner-centered curriculum should be designed according to 21st-century skills [2]. The use of Microsoft PowerPoint which is commonly used makes students passive elements in the learning process. Therefore, advanced ICT is needed to produce an interactive learning process. One technology that can present a three-dimensional view of two-dimensional objects is Augmented Reality (AR) technology [4].

AR is a 3D digital space system that refers to a virtual interface that combines real images in digital perception (virtual) with the physical environment as additional information combined scene in a real setting generated through the computing device [5], [6], [7]. AR has been implemented and has effectively increased the progress of various fields, one of which is education, namely pedagogical results and learning / academic achievement [5], [8]. AR enriches teaching tools as an effective tool for learning to explore and find out abstract concepts or complex phenomena through the interaction of objects in the real world with the virtual. AR contributes to the development of effective innovation and creativity in students and teachers in learning [6]. The AR application in education contributes to the development of this technology and adopts an integrated approach to enhance the professional level growth of students in the future of the new technological era [9].

M I S Guntur [4] from the Mathematics Education Study Program, Mathematics Education Graduate School Program, Yogyakarta State University supported his article entitled "Assessing the Potential of Augmented Reality in Education". Guntur revealed that AR was able to improve students' spatial skills, problem-solving, and motivation. There are still many student abilities that can be improved by using AR. More than 50 thousand articles on Google Scholar reveal that AR is used as a learning medium in the classroom with the keyword "augmented reality based on learning media". One of them is Nandyansah et al. [10] have developed an augmented reality based on learning media, namely Picsar (Physics Augmented Reality) to train students' proper (practical and effective) abstract thinking skills. The result is that the measured students' thinking skills are categorized as good - very good.

Because too many AR-based learning media developments have been published, the scoping method research focuses on AR-based learning assessments. One important aspect of the learning process is the assessment which is used to determine the ability of students to achieve learning goals [11], [12]. Based on the characteristics of AR technology, the assessment that has been carried out is knowledge and skills. The knowledge assessment in the form of a cognitive domain was carried out to measure the mastery of knowledge and thinking abilities of students, while the measurement of students abilities in applying knowledge to tasks is carried out by assessing the psychometric domain [13]. Thus, this study aimed to determine the use of AR in learning assessment by analyzing the results of research on developing AR-based assessment instruments.

2. RESEARCH METHODS

The review research method used is an adaptation of a scoping study from Arksey and O'Malley's [14] which aims to summarize and disseminate research findings. The five-stage frameworks used in the scoping study are 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting the data, and 5) collating, summarizing, and reporting the results.

The first research method is identifying the research question. The main question is "how is about research on AR-based assessment?". To guide data extraction and reduction, analysis, and synthesis, the sub-research questions are formulated as follows.

1) How is the evolution of the number and types of research-based AR from 2011 to 2020?
2) What institutions are most involved in carrying out this type of research?
3) What/who is the target population in the study?
4) Where is the research domain tested?
5) What are the methodologies used in the research?
6) How are the instruments used?
7) What variables are analyzed in the study?
8) What kind of AR technology is used?
9) What is the problem being analyzed?
10) What is the type of impact of the tool being analyzed?

The data were obtained through online searches on Google Scholar and related platforms using the keyword Augmented Reality based assessment for the second stage “identifying relevant studies”. The reason for choosing 'Augmented Reality based Assessment' as the keyword is to focus on searching for data that will be applied in the scope of further research. The search results using Google Scholar found 40 thousand articles which were then carried out a study selection. Study selection generates the data into 6 articles. Referring to Guntur [4], there are several criteria in selecting data as in Table 1.

The database search using the search string produces 36 articles by the intended scope. The results of all articles are available in an online database. From 36 articles, it is restricted according to the time period to 29 articles and reduced to 6 articles with a focused study on education. It is reduced again to 6 articles according to the research method and subjects that match the criteria. The data reduction chart can be seen in Figure 1.

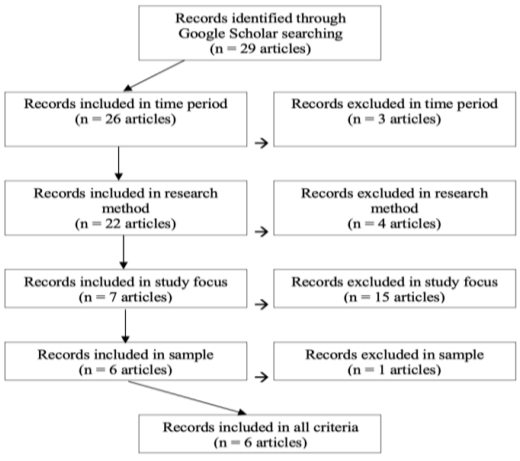

Figure 1 The data reduction chart.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Time period	The last 10 years (2011-2020)	The research more than 10 years ago
Research method	Development, R&D, quasi-experiment, mix-method	Qualitative, survey
Study focus	Education	Other than education research is not used
Sample	Student	The general public who did not or have taken education

In the fourth stage "Charting the data", the collected data is mapped based on several variables, such as author, year, subject, method, instrument, state, dependent variable, result, and suggestion. A detailed summary of the summarized variables is included and is illustrated in Table 2 and Table 3.

The results from stage 4 in Table 2 and Table 3 are summarized at stage 5 of the study. The conclusion is that all studies report that there is a positive impact on the independent variables studied. The educational level of the research subject ranges from pre-school to college. The research methods used in the development of AR-based assessment instruments are quasi-experimental, qualitative and quantitative experiments, and R&D. The instruments used in the study used an interview, questionnaire, pre-test, and post-test.

3. RESULTS AND DISCUSSION

This study aimed to analyze the development of augmented reality on the assessment instrument. Based on the year the article was published, the results of research on AR-based assessments were published annually. The research subjects were undertaken at the level of education starting from pre-school and primary school [15]–[17] to college [18]–[20]. In accordance with Dey [21] stated that AR is now used in various application domains, including Education. AR was often found to be used in science education (physics, chemistry, and biology) and has increased over the years [22], as in this research [15], [19].

Based on Table 2, a popular research method is a mix-method research. The research method that is often used is the mix-method [23], and quantitative [21]. In this study, a popular instrument used was a questionnaire, 6 out of 6 papers use it. This was also identified in Dey [21] who stated that the most popular data collection method was filling out a questionnaire, thus subjective assessment became the most widely used dependent measure.

The dependent variable that is often used and get a positive response is learning motivation [15], [17], [19]. Khan [24] in his research claimed that the use of augmented reality mobile applications can increase student motivation. Moreover, the motivation of students is the most important factor affecting the behavior of students to use the AR learning system [25].

Based on the analysis of Table 2 and Table 3, it can be concluded that the six articles analyzed state that the use of AR can increase the dependent variable and has a very positive impact on the education sector. There have been many learning media developed based on AR. To complement the learning instrument, it is also necessary to develop an AR-based assessment instrument. In addition to the 6 articles above, Ibáñez et al. [26] stated that an integrated assessment design with AR is required. Ibáñez [26] said 3 scenarios show how to design authentic and meaningful assignments by combining physical and digital spaces that students can practice their problem-solving skills.

Research suggestions from 6 articles in Table 2 and Table 3 require further development in future research because it is necessary to expand the content of other learning materials that need to be integrated with AR. A study has also identified relevant aspects to identifying the benefits of AR technology in enhancing the learning process which requires further research [23].

The development of AR technology in education has advantages and disadvantages of using in learning. By analyzing the conditions and realities that exist in schooling today and explained about the strengths, weaknesses, opportunities, and threats faced. The existence of social and real-world interaction, mostly frictionless, limited extra hardware required for mobile executions, next generation of pamphlets, and make translations simple and effective, be a big advantage in its development [27]. The disadvantages of that technology are technological maturation, mass-

market share, lack of content, limited immersion, lack of pedagogical design, and difficulties with development. The opportunities of using AR-based assessment are growing in popularity (future trend), be interactive assessment, continuous development, and many materials and subjects that still need to be developed. As for the threats of AR on education are not a perfect technology, not currently usable for everyone, and the contents are usually harnessed – and not created – by educators [28].

Table 2. Studies included in scoping review

Variables	Article 1	Article 2	Article 3
Researcher	K K Bhagat, et al	K H Chao, et al	J F Torregrosa, et al
Year	2018	2016	2015
Title	"To use augmented reality or not in formative assessment: a comparative study." [15]	"Integration of Mobile AR Technology in Performance Assessment." [18]	"ARBOOK: Development and Assessment of a Tool Based on Augmented Reality for Anatomy." [19]
Subject	70 students from grade 4 elementary school	50 sophomore students in the culinary department of a technical institute	211 students from 7 universities (public and private) in Spain
Country	Taiwan	Taiwan	Spain
Method	Quasi-experimental research design	Qualitative and quantitative research designs	Mix-method
Instrument	Pre-test, post-test, and motivation questionnaire	Assessment on papers and mobile devices (use MARPAS), questionnaire, interviews	Specific questionnaire of three blocks
Dependent variables	learning performance and motivation	Performance Assessment	Attention–motivation, autonomous work, 3D-comprehension tasks
Result	AR-based formative assessment has positive effects on helping increase student motivation and achievement compared to conventional methods [15].	The data collected by the experiment between pen-and-paper assessment and MARPAS assessment showed that students agreed on the positive effects of AR, cellular services, and confirmed the usefulness of AR technology in learning [18].	The results strongly suggest that the use of AR is suitable for research anatomical purposes on attention-motivation, autonomous work, and 3D-comprehension tasks found statistically significant better scores for the ARBOOK group in the written test [19].
Product	An AR-based formative scoring system, as 3D AR butterflies	Mobile AR performance assessment system (MARPAS)	Augmented Reality Book (ARBOOK) Part I. Lower limb
Suggestions	There are still many things to investigate and explore regarding formative assessment based on AR, and no potential conflict in this study [15].	Photographers are needed by students when not working in groups, and this can be met with new technology tools such as Google Glass [18].	The use of AR has to be given more consideration at the present moment [19].

Table 3. Studies included in scoping review

Variables	Article 4	Article 5	Article 6
Researcher	M C Juan, et al	Z Syarifudin, Suharjito	E Ibili, et al
Year	2014	2020	2019
Title	"Augmented Reality for the Assessment of Children's Spatial Memory in Real Settings." [16]	"Mobile Based for Basic English Learning Assessment with Augmented Reality." [17]	"An assessment of geometry teaching supported with augmented reality teaching materials to enhance students' 3D geometry thinking skills." [20]
Subject	76 children aged 5–8 years (preschool and primary school)	34 students of Grade 4 at an elementary school	Students (no specific)
Country	Spain	Indonesia	Turkey
Method	Mix-method	Mix-method	Quantitative
Instrument	Tasks (ARSM task and AWMA Dot), AR-questionnaire	Pre-Test, Post-Test, attitude questionnaire	Pre-test, post-test
Dependent variables	ARSM task variables, satisfaction, and usability	Learning motivation, student acceptance, learning outcomes	Thinking skills
Result	In the normal age of the child (5–8 years), performance on the ARSM task demonstrated improved short-term memory, the similarity in daily spatial memory activity, and traditional measures of visuospatial short-term memory [16].	There is a positive response to the results of the evaluation of the AR application from students, with the advantages that have been designed are being able to display 3D models, animation, sound, text, assessment, and feedback [17].	Geometry learning supported by AR was able to improve students' 3D thinking skills with statistical differences found in supporting the experimental group for the entire scale ($p < 0.05$) [20].
Product	ARSM (Augmented Reality Spatial Memory) task	Mobile Based Assessment with Augmented Reality	Augmented Reality Geometry Tutorial System (ARGTS)
Suggestions	ARSM tasks can be used to assess or train children in short-term spatial memory skills as an entertaining method (further research needs to be done) [16].	Expansion of the content of learning materials in further research to fulfill the competency standards of students [17].	Further research on the use of AR applications is needed by teachers so that teaching materials can be shared easily and instantly [20].

4. CONCLUSION

The research results in this article aim to determine the application of AR in the development of assessment instruments in education. All studies reported that there was a positive impact on the independent variables studied, such as student motivation and performance, and much potential could be further developed by using AR in learning assessment instruments. Because few articles discuss AR-based learning assessment, future research needs to develop the use of AR in other materials and subjects.

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