Impact of Using Augmented Reality On Students' Cognitive and Affective Aspects in Terms of Education Level

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Abstract: Many studies related to the use of Augmented Reality (AR) in the learning process. However, not many researchers have studied the effect of using AR on affective and cognitive aspects in terms of education level. To uncover this problem, the researcher uses a systematic literature review (SLR) design. In this study, the SLR stage consisted of four stages (1) problem formulation; (2) literature search; (3) identification of the type of research; (4) information retrieval. The findings of this study reveal that the use of AR technology has an effect on cognitive and affective aspects at the elementary and high school education levels. Middle school is the level of education that mostly applies AR technology. This study provides a recommendation that AR technology can be a medium for learning mathematics that can be applied by teachers and students at the primary and secondary education levels.

Keywords: Augmented Reality; Cognitive Aspect; Affective Aspect; Education Level.

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Introduction

The use of AR technology has been widely used in various fields, one of which is education (Hanan et al., 2018; Sudirman et al., 2021). The use of AR in education has grown rapidly over the past decade (Sudirman et al., 2022). The use of AR has also changed the interaction of the learning process in the classroom(Mustaqim & Kurniawan, 2017) and has had a positive influence on the learning process (Mauludin et al., 2017). At the school level, from elementary to high school, the use of AR has helped can help students understand science and mathematics material. The existed characteristics in AR make students more interested in learning, this makes students more active and motivated to learn (Sudirman et al., 2020). In addition, the use of AR in learning will also be more effective and interesting because it has more perspectives when compared to conventional learning (Diegmann et al., 2015). This has an impact on improving the cognitive, affective, and psychomotor aspects of students. The many benefits provided by AR in learning and using AR which have been implemented at various levels make researchers interested in analyzing according to their level of education. However, the use of AR in learning also has many obstacles in the process, namely: (a) Problems when downloading the program on the instructor's and student's cell phones; (b) Marker constraints related to AR identification; (c) Limits on students' smartphone needs; (d) Network restrictions and restrictions on accessing the Resources section; (e) Students find too many constraints on the assessment questions on the test list (Sudirman, et al., 2021).

Researchers have studied the use of AR technology in learning, both at the school and college levels. As was done by Diegmann et al. (2015) in his research which focused on the benefits of AR technology related to the types of applications used, many applications have successfully implemented AR to enhance learning such as language education, mechanical skills training, and spatial ability training. Research conducted by (Ahmad & Junaini, 2020) in his research focused on tools and applications, student difficulties, frequently used material topics, and methods used to process data.

Systematic Literature Review (SLR) is a literature review used to identify and synthesize relevant studies. Systematic means that a systematic review has a set of standards on how a systematic review can be used (Sulaiman & Azizah, 2020). Therefore, this study aims to systematically examine the results of research published in international journals regarding the application of augmented reality technology in mathematics education and its effect on the cognitive and affective aspects of students at every level of education in schools.

Research Method

This study uses a systematic literature review (SLR) method. This is done by systematically reviewing and identifying journals or literature, through the SLR steps consisting of four stages, namely: problem formulation, literature search, literature analysis, and concluding (Mulligan et al., 2020). Researchers used software from database sources: emerald, link springer, ScienceDirect, Taylor and Francis journal, and google scholar. Using Search code: Augmented Reality, mathematics. The results of the search are presented in the following Table 1.

Table 1 Source Database Journal

Source Database	Number of articles	Relevant Literature
https://www.springer.com/gp	319	2
https://www.emerald.com/insight/	20	-
https://www.sciencedirect.com/	93	2
https://www.tandfonline.com/	43	11
https://scholar.google.com/	33	1

Most researchers use AR in the fields of business management, advertising, and aviation schools. Articles that have been collected will be analyzed according to predetermined criteria. In this study the research criteria include:

a) Themed article about the Augmented Reality (AR) method in learning mathematics.
b) Articles published within the last 6 years starting from 2015-2020.
c) Articles made using experimental and non-experimental research methods.
d) The sample level of education in the article is the level of education in Primary School, Secondary School.
e) The articles used have been indexed by Scopus.

Result and Discussion

Result

Educational level is the stage of education that is determined based on the level of development of students, the goals to be achieved, and the capabilities developed. Formal education levels consist of basic education, secondary education, and higher education. The following is a table of the results of the analysis of education levels that apply AR in learning mathematics (Table 2).

Table 2 Results of Educational Level Analysis

Name of Researcher	Educational Level	Frequency
Sarkar et al. (2020); Gargrish et.(2021); Ibáñez et al. (2020); Elsayed & Al-najrani (2022); Cai et al. (2019); Cai et al. (2020) Sudirman et al. (2021); Lin, et al. (2015); Rohendi et al. (2018); Aldalalah et al. (2019)	Secondary school	10
Ozcakir & Cakiroglu (2021); Gecu-Parmaksiz & Delialioglu (2019); Liu, et al. (2019); Papanikolaou et al. (2016); Chang et al. (2016)	Primary school	5
Cascales-Martínez et al. (2017)	SLB	1

In Secondary School, 5 kinds of literature apply AR at the primary school education level, and one literature that applies AR in special schools. So that the use of AR is most often applied at the secondary education level. The dependent variable is a variable that is used to test a certain independent variable or treatment to determine whether the independent variable or treatment can affect the targeted dependent variable.

Table 3 Results of AR Effect Analysis Based on Education Level and Bound Variables

Name of Researcher	Educational Level	Dependent Variable	Outcome
Rohendi et al. (2018)	Secondary school	Motivation to learn	Take effect
Chen et al. (2019)	Primary school		
Elsayed & Al-najrani (2022)	Secondary school		
Sarkar et al. (2020)	Secondary school		
Ibanez et al. (2020)	Secondary school		
Chang et al. (2016)	Secondary school		
Cascalez-Martinez et al. (2016)	School for Special Needs Children (SLB)		
Aldalalah et al. (2019)	Secondary school	Visual Ability	Take effect
Ibili et al.(2019)	Primary school		
Lin et al. (2015)	Secondary school		
Chen et al. (2020)	Primary school	Learning outcomes	Take effect
Cai et al. (2019)	Secondary		

	school		
Ibanez et al. (2020)	Secondary school		
Gecu-Parmaksiz & Delialioglu (2019)	Primary school	Conceptual Understanding	Take effect
Gargarish et al. (2020)	Secondary school		

In Table 3 above, four variables are the same with samples of different levels of education, namely learning motivation, visual ability, learning outcomes, and conceptual understanding. These four variables have been applied at several levels of education, including primary and secondary education, and are also applied to special schools or special schools. The results of this analysis show that AR has a good influence on the observed variables even with different levels of education.

Discussion

In Table 2 there are 10 of the 16 literature that apply AR at the secondary school education level, there are 5 literatures that apply AR at the primary school education level, and one literature that applies AR in special schools or special schools. Therefore, in this study, AR is more often used in mathematics learning at the secondary education level. Mathematics is a subject that has been taught since students were still in primary school However, at the basic level of course the material provided is not too complex and complicated considering that at this stage students are taught with concrete media. As stated by Jean Piaget regarding the stages of thinking in children, it is divided into 4 stages, namely: the sensor-motor stage, the pre-operational stage, the concrete operational stage, and the formal operational stage (Marinda, 2020).

The formal operational stage is a stage that occurs in high school students and beyond, in addition to broader and complex material, at this stage, they also begin to be taught with symbols and abstracts that allow students to have qualified visual abilities. The use of AR that is more often applied in secondary schools may occur because of the needs of students who are in a transition period from understanding through concrete objects to something symbolic, so there needs to be a link that makes it easier for students to understand symbols through non-concrete visual understanding. AR is designed to be able to recognize certain symbols which will then be processed so that they can display visual effects in the real world but are not concrete, therefore AR is more often used at the secondary school education level.

Conceptual ability is one of the key aspects of a learning process (Runisah et al., 2021). One of the learning objectives is to make students understand the main concepts in a subject, not just remembering isolated facts. Conceptual ability will develop if the teacher can help students explore topics in-depth and provide them with appropriate and interesting examples of a concept (Sudirman et al., 2020). Tests on conceptual ability were carried out by two researchers at the elementary (Gecu-Parmaksiz & Delialioglu, 2019) and junior high (Gargrish et al., 2020) levels. The test results found that AR can improve students' conceptual abilities, this can happen because AR can provide interesting and interactive illustrations or examples, so students will better understand concepts in learning.

Visual ability or visual thinking is one of the basics of spatial thinking in mathematics, visual abilities are divided into three, namely seeing, imagining, and drawing (Mulligan et al., 2020). Tests on visual abilities were carried out by three researchers, two of whom used a sample of junior high school students (Aldalalah et al, 2019; Lin et al, 2015), and one at the elementary level (Tosik & Atasoy, 2017) . The use of AR is proven to improve students' visual abilities; this may happen because AR is a technology that can visualize a virtual object into a real environment. So that AR can improve students' visual abilities.

Learning outcomes are the result of a person's learning process, learning outcomes are related to changes in the person who learns. Forms of change as a result of learning include changes in knowledge, understanding, attitudes, and behavior, skills, and abilities (Sudirman et al., 2020). Change as a result of learning is relative, permanent, and has the potential to develop (Kartini et al., 2020). Tests on learning outcomes were carried out by three researchers, two of whom used a sample of junior high school students and one at the elementary level. The results of this study indicate that AR can improve student learning outcomes.

Learning motivation is an effort that is made consciously in carrying out learning activities to achieve a certain goal such as learning achievement or learning outcomes. Tests on learning motivation were conducted by seven researchers, five studies were conducted in junior high schools, one study was conducted in elementary schools and another study was conducted in elementary schools done in SLB.

Conclusions

The results of the study show that the use of AR in learning mathematics can improve various cognitive aspects such as visual thinking skills, learning outcomes, and conceptual understanding. Can improve effective aspects such as student motivation. Although applied

to different levels of education. The use of AR in learning mathematics has been used at several levels of education such as elementary, junior high, high school, and university. The results of this study indicate that AR is more often applied at the secondary education level. This research is limited by literature sources, years, and education level. For future researchers, the authors suggest adding literature sources, years, and levels of education. Can also analyze related to the use of AR seen from the material and aspects of observation and the use of AR seen from the material and level of education.

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