OmniaScience

Journal of Technology and Science Education
JOTSE, 2023 – 13(3): 597-612 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349
https://doi.org/10.3926/jotse.1813

AUGMENTED REALITY ON STUDENTS' ACADEMIC ACHIEVEMENT VIEWED FROM THE CREATIVE THINKING LEVEL

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Received June 2022
Accepted April 2023

Abstract

The use of computer applications as learning media has been widely used in the learning process. One such computer application is Augmented Reality. Augmented Reality has advantages in ease of use, media appeal, and mobility because it can be used on cell phones and tablets. Creative thinking is a skill that students need in solving problems in a learning process in the classroom. The research objective is to investigate the effect of augmented Reality on students' academic achievement viewed from the creative thinking level. MANOVA was used to analyze differences in cognitive and psychomotor learning outcomes between the experimental class using AR and the control class using PowerPoint. The results showed that learning media and creative thinking levels affect cognitive and psychomotor learning outcomes. Cognitive learning outcomes of students using AR are higher than student learning outcomes using PowerPoint. Meanwhile, the psychomotor learning outcomes of students using AR are higher than those using PowerPoint. The learning media significantly affects cognitive learning outcomes with a p-value = 0.007, while the creative thinking level significantly affects psychomotor learning outcomes with a p-value = 0.016.

Keywords **–** Augmented reality, Creative thinking level, Academic achievement, MANOVA, Learning media.

To cite this article:

Buditjahjanto, I.G.P.A., & Irfansyah, J. (2023). Augmented reality on students' academic achievement viewed from the creative thinking level. *Journal of Technology and Science Education,* 13(3), 597-612. https://doi.org/10.3926/jotse.1813

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1. Introduction

The development of computer applications in the visual field has been overgrown; one is Augmented Reality. Augmented Reality is a technology that integrates two or more dimensional virtual objects into real three-dimensional, furthermore projects those virtual objects in real-time. The results of these virtual objects can look the same in the real world (Zheng, 2015). Augmented Reality development is so widespread because Augmented Reality has characteristics such as being real-time, being in 3D form, and interactively with users as if interacting with the natural world (Alkhamisi & Monowar, 2013; Azuma, Baillot, Behringer, Feiner, Julier & MacIntyre, 2001). Augmented Reality applications have been widely applied, such as in the fields of medicine, commerce, advertising, entertainment, and design (Carvalho &

Morais-Lemos, 2014; Hsu, Lin & Yang, 2017; Tsai & Yen, 2014). Augmented Reality in education has been widely applied to assist students in understanding a learning material. Augmented Reality in education has been widely used as an instructional tool in carrying out laboratory experiments (Onime & Abiona, 2016), a learning medium to be used in studying the character of aquatic organisms (Tsai & Yen, 2014), as a learning medium in geometric lessons because it can visualize geometric concepts in real so that it can facilitate students' understanding (Carvalho & Morais-Lemos, 2014).

In the educational aspect, the advantages of Augmented Reality to be applied to the learning process are that Augmented Reality can be used to access virtual materials from learning even when students are outside the classroom or laboratory, Augmented Reality makes it easier for students to study, and manipulate fragile and expensive objects, such as viscometers via mobile devices, and view demonstration videos with other mobile devices when working in small groups (Efrén-Mora, Carrau-Mellado & Añorbe-Díaz, 2013). Augmented Reality technology can use handheld devices such as tablets and smartphones to be operated mobile. It can attract students' attention by visualizing information content on natural objects (Majid, Mohammed & Sulaiman, 2015). Augmented Reality technology applied in the classroom supports explaining concepts by adding information to things recorded by mobile devices. This technology counts on the image feature analysis and the combined use of software applications that store data with authentic images. Learning using Augmented Reality can improve student achievement (Fombona-Cadavieco, Goulão & Fernandez-Costales, 2012). According to Chang, Kang and Huang (2013), Augmented Reality as an instructional tool can significantly improve students' responses, improve job skills competency during the intervention phase, and maintain work skills acquired after intervention from students. Furthermore, Chiang, Yang and Hwang (2014) state that Augmented Reality -based inquiry learning activities can involve students in more interactions to build knowledge.

In the existing research, not many in-depth discuss the effect of Augmented Reality as a learning medium on student learning outcomes in terms of the level of creativity. Therefore, it becomes a research gap that can be done in this study. This research is conducted at a vocational high school in Indonesia on computer assembly. The problem in learning computer assembly that many students complain about is understanding the process and steps of computer component assembly. Meanwhile, the computer assembly subject requires students to understand and identify the hardware of computer components and learn how to assemble those components on computers correctly. This study is different from previous research because this study investigates the effect of the relationship between the creativity skills level of students on academic achievement.

Measurement of learning outcomes in computer assembly subjects consists of two types, namely: (1) cognitive learning outcomes to measure students' understanding to identify the hardware of computer components and to explain how those computer components work; (2) psychomotor learning outcomes to measure students' practical skills on the computer assembly process. This study also investigated the creative thinking level of students. Creativity thinking was chosen for this research; according to O'Reilly (2016), creativity-based learning is needed in a vocational education environment to encourage students to think creatively, produce quality learning, and have higher creative levels of work. Creative thinking has a significant positive relationship with scientific process skills scores and student academic performance (Yildiz & Yildiz, 2021).

Research conducted by Yang and Zhao (2021) shows that creative thinking affects learning outcomes. The elements of creative thinking include students' self-esteem and internal locus of control. It is also supported by Akpur (2020), which states that creative thinking is positively and significantly correlated with learning outcomes. The research objective is to investigate the effect of augmented Reality on students' academic achievement viewed from the level of creative thinking.

The research aims to investigate the effect of augmented Reality on students' academic achievement viewed from the creative thinking level. This study consists of two groups. The student group who learned computer assembly through Augmented Reality as learning media and another student group who knew computer assembly through PowerPoint as teaching media, the research question for this study are:

a) Is the average value of student learning outcomes using Augmented Reality higher than PowerPoint's?, b) Is there a significant difference between the use of learning media toward their cognitive academic achievement and psychomotor academic achievement?, c) Is there a significant difference between their level of creative thinking toward their cognitive academic achievement and psychomotor academic achievement?

2. Literature Review

2.1. Augmented Reality

This study consists of two groups. The student group who learned computer assembly through Augmented Reality as learning media and another student group who knew computer assembly through PowerPoint as teaching media, the research question for this study are: a) Is the average value of student learning outcomes using Augmented Reality higher than PowerPoint's?, b) Is there a significant difference between the use of learning media toward their cognitive academic achievement and psychomotor academic achievement?, c) Is there a significant difference between their level of creative thinking toward their cognitive academic achievement and psychomotor academic achievement?

Augmented Reality technology allows users to see and observe virtual objects in 2D or 3D projection onto an entire system. Augmented Reality is a technology that can combine digital content created by computers with real systems in real-time (Onime & Abiona, 2016). Augmented Reality technology can become a learning medium because of its ability to integrate tangible objects into virtual objects in a natural environment, real-time interactive execution with real and virtual objects, and convey information to support the learning process (Ke & Hsu, 2015). Augmented Reality can be used as a learning medium to deliver learning materials in a learning process. The application of Augmented Reality as a learning medium can motivate students and positively influence student learning outcomes in studying STEM material (Science, Technology, Engineering, and Mathematics) (Hsu et al., 2017). The benefits of augmented reality media for learning are: (1) augmented reality media makes objects more straightforward and more natural so that students seem to see the object actually in front of them; (2) augmented reality media can improve student learning outcomes because virtual objects that are displayed are more attractive, can be viewed longer and can be displayed repeatedly so that through their attractiveness they can motivate students to learn; (3) Augmented reality media is relatively efficient because with augmented reality-based multimedia it is not necessary to bring visual aids into the classroom, but phenomena associated with the material being learned can still be displayed in the classroom.

2.2. Dimensional and Levels of Creativity

Experts have expressed several definitions of creativity. They propose that the purpose of reactivity consists of at least four components, namely: (1) creative process; (2) creative products; (3) creative persons; and (4) creative situations (Heilman, 2005). The four components generally apply that creativity is an essential aspect of scientific ability, such as problem-solving, generation, hypotheses, experimental design, and innovation that require particular forms of scientific creativity (Lin, 2011).

According to Torrance (1968), it must consist of four dimensions: fluency, originality, elaboration, and flexibility to measure creative thinking. The instruments developed to measure creative thinking refers to these four dimensions. The instrument is often called the Torrance Tests of Creative Thinking (TTCT). The use of the TTCT instrument is still relevant today in determining a person's creativity score (Runco, Millar, Acar & Cramond, 2010).

The use of creative thinking in learning material in the classroom can benefit students to develop their ability to establish themselves. Creative thinking applied in learning correlates to students' achievement positively (Gajda, 2016). The use of creative thinking in Robotic learning materials shows a statistically significant contribution to students' problem-solving skills (Çakır, Korkmaz, İdil & Erdoğmuş, 2021).

According to Huang, Chang and Chou (2020), measurement of the influence of creativity is needed to determine the ability of students to develop their innovative work in engineering design creativity of

students. The results of measuring student creativity can also be grouped into several levels. As the research was done by Siswono (2011), the study applied the TTCT instrument to get a student's creativity score. Furthermore, these scores of creativity were divided into five levels. The order of creativity skill level from high to low is as follows: Level 4 (Very Creative), Level 3 (Creative), Level 2 (Quite Creative), Level 1 (Almost Not Creative), and Level 0 (Not Creative). Table 1 shows leveling of creative thinking.

Level	Characteristic of creative thinking level
Level 4 (Very Creative)	Students satisfied all components of creative thinking or only flexibility and novelty in solving and posing problems.
Level 3 (Creative)	Students were fluent, and then they were flexible or demonstrated novelty, but not both in solving and posing problems.
Level 2 (Quite Creative)	Students were able to show flexibility and novelty in solving and posing problems without fluency.
Level 1 (Almost Not Creative)	Students were able to show fluency without novelty and flexibility in solving and posing problems.
Level 0 (Not Creative)	Students were not able to show any components of creativity.

Table 1. Leveling of Creative Thinking

3. Method

3.1 Research Design

This study used a quasi-experimental research design. This study consists of two groups: the experimental and control groups. The experimental group is the student group that learned computer assembly through Augmented Reality as learning media. The control group is the student group that learned computer assembly through PowerPoint as a learning media.

3.2. Participants

The participants of this study consisted of 60 students of class X at Vocational High School Surabaya-Indonesia. Furthermore, the 60 students were divided into 2 groups: the control class composed of 30 students, and the experimental class composed of 30 students. The experimental class was taught using Augmented Reality, and the control class was taught using PowerPoint. The learning model used in this research is Problem-Based Learning. Figure 1 shows the Augmented Reality for learning computer assembly.

Figure 1. Augmented Reality for learning computer assembly

3.3. Data Collection Tools

3.2.1. Instrument Validity and Reliability

In this study, regarding the validity of the instruments for face validity evidence, we used three experts to check whether the statements in the instrument are clear and appropriate. Some revisions were done

to the instrument based on the experts' comments. Furthermore, a group of 30 students had been employed as participants to measure the instrument's reliability. Those students did not participate in the final study.

3.2.2. Cognitive Learning Outcomes Test Instrument

The instrument used to measure cognitive learning outcomes is a test question consisting of 40 multiple-choice questions. Cognitive learning outcomes are scores of students' abilities in terms of intellectual capability, which means knowledge, knowing, or thinking. According to the syllabus, these items include essential competencies which explain the computer installation procedure. The validation results from three validators have a mean value of > 80% (very valid). The validation steps of the three validators can be seen in Table 2 and Table 3. Table 2 shows an example of cognitive test validation on question number 1. Table 3 shows the recapitulation of cognitive test validation.

Question Number		**1**		
Validator		**V1**	**V2**	**V3**
	Assessment Indicators			
A	***Learning material***			
1	Following the indicators for the preparation of the questions.	4	4	5
2	The material question is under the composition (urgency, relevance, continuity, applicable).	4	4	5
3	Homogeneous and logical answer choices.	4	4	4
4	There is only one answer.	5	5	5
B	***Construction***			
1	The subject matter is formulated briefly, clearly, and assertive.	4	5	5
2	The main questions and answer choices are statements that are needed only.	5	5	5
3	The subject matter does not provide an answer key clue.	4	5	5
4	The subject matter is free from statements that are double negative.	4	5	5
5	The answer choices are homogeneous and logical in terms of learning materials.	4	5	5
6	Images, graphs, tables, and diagrams, are well-viewed and functional.	5	5	5
7	The length of the answer choices is relatively the same.	4	4	4
8	The answer choices do not use the statement "All the answers above are right or wrong" and the like.	5	5	5
9	Item questions do not depend on the answer to the previous question.	5	5	5
C	***Language and Culture***			
1	The item questions use Indonesian language rules properly and correctly.	4	4	5
2	Use communicative language.	4	5	5
3	Do not use the local language.	5	5	5
4	The answer choices do not repeat the same word or group of words unless it is a unified understanding.	5	5	5
5	The question sentence does not copy a reading text.	4	4	5
6	The sentence in the subject matter does not offend a person's personality, ethnicity, race, and religion.	5	5	5
	Sum	84	89	93
	Total sum			266
	Percentage (%)	266/(19*5*3) *100= 266/285*100= 93		
	Category	Very Valid		

Table 2. An example of cognitive test validation on question number 1

No	V1	V2	V3	Total	Percentage (%)	Category
1	84	89	93	266	93	Very Valid
2	90	90	92	272	95	Very Valid
3	80	84	87	251	88	Very Valid
4	77	82	85	240	86	Very Valid
5	90	93	93	277	97	Very Valid
6	84	89	91	264	93	Very Valid
7	78	83	88	246	87	Very Valid
8	80	83	86	249	87	Very Valid
9	78	81	84	243	85	Very Valid
10	78	80	82	240	84	Very Valid
11	83	84	88	255	89	Very Valid
12	78	83	83	244	86	Very Valid
13	80	81	83	244	86	Very Valid
14	82	86	86	254	89	Very Valid
15	74	75	76	225	79	Valid
16	84	84	84	252	88	Very Valid
17	87	88	88	262	92	Very Valid
18	84	85	85	254	89	Very Valid
19	76	77	75	228	80	Valid
20	87	88	88	263	92	Very Valid
21	84	84	84	252	88	Very Valid
22	87	87	87	261	92	Very Valid
23	84	84	84	252	88	Very Valid
24	87	88	88	263	92	Very Valid
25	84	84	84	252	88	Very Valid
26	85	86	89	260	91	Very Valid
27	87	88	88	263	92	Very Valid
28	82	82	82	246	86	Very Valid
29	84	84	84	252	88	Very Valid
30	71	81	81	233	82	Very Valid
31	80	89	91	260	91	Very Valid
32	83	87	87	257	90	Very Valid
33	81	85	85	251	88	Very Valid
34	81	84	84	249	87	Very Valid
35	74	79	79	232	81	Very Valid
36	82	81	83	246	86	Very Valid
37	81	83	83	247	87	Very Valid
38	76	77	75	228	80	Valid
39	79	81	81	241	85	Very Valid
40	82	83	83	248	87	Very Valid
				Average Overall	87.85	Very Valid

Table 3. Cognitive test validation recapitulation

The results of running SPSS show that 30 students have filled in all and gave valid results, as shown in Table 4.

The Cronbach's alpha reliability was 0.713 for the overall scale, ranging from 0.645 to 0.714 for the subscales. Table 5 shows that all 40 question items are reliable because of Cronbach's Alpha (0.713) > 0.6.

		N	%
Cases	Valid	30	100.0
	Excluded	0	.0
	Total	30	100.0

Table 4. Case Processing Summary for Cognitive Test Items

Cronbach's Alpha	N of Items
0.713	40

Table 5. Reliability Statistics for Cognitive Test Items

3.3.3. Psychomotor Learning Outcomes Test Instrument

Psychomotor learning outcomes are scores of students' abilities in performing physical activities. Psychomotor learning outcomes were measured using observation sheets or psychomotor observations. The validation results from 3 validators were worth 89% (very valid). The running SPSS shows that 30 students have filled in all and gave valid results, as shown in Table 6.

Table 7 shows the indicators of the psychomotor assessment consisting of 12 items and the results of running SPSS for the validity of the psychomotor assessment. The validity results show that all items are valid because of the value of $r_{count} > r_{table}$ (0.361). Table 8 shows that all 12 question items are reliable because of Cronbach's Alpha (0.643) > 0.6.

Table 9 shows an example of an observation instrument of psychomotor performance assessment for indicator number four, namely installing the memory module

		N	%
Cases	Valid	30	100.0
	Excluded	0	.0
	Total	30	100.0

Table 6. Case Processing Summary for PsychomotorAssessment Items

No	Indicators of psychomotor Assessment	r_{count}	r_{table}	Validity
1	Preparing tools and materials for component assembly motherboards.	0.629	0.361	valid
2	Installing the chip and socket processor.	0.652	0.361	valid
3	Installing the heatsink.	0.648	0.361	valid
4	Installing the memory module.	0.591	0.361	valid
5	Installing the motherboard on the case.	0.621	0.361	valid
6	Installing the power supply.	0.622	0.361	valid
7	Installing connector cables such as LEDs, internal speakers, mouse, keyboard, and ports on the computer case.	0.574	0.361	valid
8	Connecting the IDE cable connector to the drive and connector.	0.625	0.361	valid
9	Installing the adapter card in the motherboard slot.	0.625	0.361	valid
10	Checking all installed components properly.	0.625	0.361	valid
11	Testing performance of all PC hardware.	0.627	0.361	valid
12	Handling problems with computer assembly results.	0.625	0.361	valid

Table 7. Indicators and Validity of PsychomotorAssessment

Cronbach's Alpha	N of Items
0.643	12

Table 8. Reliability Statistics for Psychomotor Test Item

No	Psychomotor Task Details	Maximum Score	Teacher Assessment Score
1	To prepare the tools and materials needed	25	
2	To connect the tools and materials as shown in Figure 2 of the student worksheet.	25	
3	To check whether the RAM is installed correctly	25	
4	To operate the circuit according to the procedures written in the student worksheet.	25	
	Score Total	100	

Table 9. Psychomotor Performance Assessment for Installing Memory Module

3.3.4. Creative Thinking Test Instrument

The creative thinking test instrument used refers to the Scientific Structure Creativity Model (SSCM) developed by Hu and Adey (2002). The assessment of creativity level is measured after the entire learning process has been completed. Table 10 shows the results of running SPSS. It shows that 30 students have filled in all and gave valid results.

Table 11 shows reliability statistics for creativity assessment items. It shows that all 7 question items are reliable because the score of Cronbach's Alpha is 0.876 > 0.6.

		N	%
Cases	Valid	30	100.0
	Excluded	0	0.0
	Total	30	100.0

Table 10. Case Processing Summary for Creativity Assessment Items

Cronbach's Alpha	N of Items
0.876	7

Table 11. Reliability Statistics for Creative Thinking Assessment Items

Table 12 shows the validity of the creative thinking assessment. It shows the indicators of the creativity assessment consisting of 7 items and the results of running SPSS for the validity of the creative thinking assessment. The validity results show that all items are valid because of the value of $r_{count} > r_{table}$ (0.361).

Table 13 shows the rubric of creative thinking test questions. This rubric refers to the indicators from the Torrance Test of Creative Thinking (TTCT) and also adapts from Hu and Adey (2002). This rubric consists of seven questions that measure fluency, flexibility, originality, problem-finding, product development, problem-solving, scientific experiments, and product design.

No	Indicators of Creative Thinking Assessment	r_{count}	r_{table}	Validity
1	Write down as many tools that function as input media!	0.618	0.361	valid
2	Suppose a school requires a computer to introduction to computer practice and information and communication technology practice. Write down the sequence of steps in compiling a minimum PC specification that can meet these needs!	0.833	0.361	valid
3	Write down as many ways as possible to fix the hardware condition on a computer that will not turn on!	0.803	0.361	valid
4	Write down as many problems and causes as possible! If the computer assembled by the student does not turn on?	0.618	0.361	valid
5	Write down and explain as many methods as possible that can be used if an error occurs plugging the components used to assemble the computer!	0.803	0.361	valid
6	How to find out which technology is the safest for most users using two different peripheral technologies! Write down as many methods, instruments, principles, and simple procedures as possible!	0.833	0.361	valid
7	PC components or peripherals are provided. Assemble the components /peripherals so that they can function as a PC!	0.803	0.361	valid

Table 12. Validity of Creative Thinking Assessment

Question Number	Question Items Description	Assessment
1-4	Unusual use, problem finding, development product, scientific imagination.	Fluency: 1 point for each answer. Flexibility: 1 point for each answer. Originality: < 5% = 2 points 5% - 10% = 1 point > 10% = 0 points
5	Problem Finding	Fluency and Originality < 5% = 3 points 5% - 10% = 2 points > 10% = 1 point Maximum points = 9 (1 method)
6	Scientific experiment	a. Instrument = 3 b. Principle = 3 c. Procedure = 3 Point 18 (2 methods)
7	Product design	Originality: < 5% = 4 points 5% - 10% = 2 points > 10% = 1 point Each function = 3 points

Table 13. The rubric of Creative Thinking Test Questions

3.4. Data Analysis

The MANOVA method was used for data analysis. The MANOVA can analyze the relationship between the response variable vectors, influenced by several treatments. If Y is the dependent variable and X is the independent variable, then the MANOVA modeling of this study is as follows:

$$Y_1 + Y_2 = X_1 + X_2$$

$$Y_{cognitive} + Y_{psychomotor} = X_{media} + X_{creative}$$

Where:

Learning Media (X_1)

- Media = 1: Augmented Reality
- Media = 2: PowerPoint

Creativity Thinking Level (X_2)

- Creative = 0: Not Creative
- Creative = 1: Less Creative
- Creative = 2: Fair Creative
- Creative = 3: Creative
- Creative = 4: Very Creative

Domain Learning Outcome (Y_1)

- Cognitive = Cognitive Learning Outcome

Domain Learning Outcome (Y_2)

- Psychomotor = Psychomotor Learning Outcome

4. Result

4.1. Development of Academic Achievement

The independent variables of this study consisted of learning media and creative thinking levels. These independent variables are categorical. Learning media has two categories there are category 1 for Augmented Reality and category 2 for PowerPoint. Each of these learning media is applied to 30 students as participants. Furthermore, the testing results of measuring students' creative thinking levels can classify three category levels from 5 category levels for creative thinking. The level categories are level 4 for a very creative category with five students, level 3 for a creative category with 40 students, and level 2 for a fair creative category with 15 students. Table 14 shows the dependent variable and its level categories.

		Value Label	N
Learning Media	1	Augmented Reality	30
	2	PowerPoint Slide	30
Creative Thinking Level	2	Fair creative	15
	3	Creative	40
	4	Very Creative	5

Table 14. Dependent variables and their level categories

The processing of research data into descriptive statistics is shown in Table 15. Table 15 shows that students who apply Augmented Reality have a total average cognitive learning outcome of 82.0167. Meanwhile, the total average cognitive learning outcome for students who use PowerPoint is 75.8167. It can know that the Creative Thinking Level for Augmented Reality consists of two levels, namely Creative (level 3) composed of 25 students, and the Very Creative (level 4) composed of 5 students. Moreover, the Creative Thinking Level for PowerPoint consists of two levels: Fair Creative (level 2), composed of 15 students, and Creative (level 4), composed of 15 students.

Table 15 also shows that students who use Augmented Reality have a total average psychomotor learning outcome of 87.1533. Furthermore, the average total psychomotor learning outcome for students who use PowerPoint is 84.6067. Table 15 shows the Creative Thinking Level for Augmented Reality: Level 3 (Creative) consists of 25 students and level 4 (Very Creative) consists of 5 students. Moreover, the Creative Thinking Level for PowerPoint consists of two levels: level 2 (Fair Creative), which consists of 15 students, and level 4 (Creative), which consists of 15 students. The differences in levels of creative

thinking between the two learning groups show quite different results. The creativity level of Augmented Reality media on both learning outcomes (cognitive and psychomotor) showed better results than the creativity level of PowerPoint media on both learning outcomes (cognitive and psychomotor). In Augmented Reality media, the level of creativity achieved is at level 3 and level 4, while in PowerPoint media, the creativity level is shown at level 2 and level 3. The research results show that students who use Augmented Reality have a higher level of creative thinking compared with students who use PowerPoint.

	Learning Media	Creative Thinking Level	Mean	Std. Deviation	N
Cognitive Learning Outcome	Augmented Reality	Creative	81.0680	5.34125	25
		Very Creative	86.7600	5.85560	5
		Total	82.0167	5.74409	30
	PowerPoint Slide	Fair creative	75.6200	5.04214	15
		Creative	76.0133	6.10537	15
		Total	75.8167	5.50530	30
	Total	Fair creative	75.6200	5.04214	15
		Creative	79.1725	6.08925	40
		Very Creative	86.7600	5.85560	5
		Total	78.9167	6.39436	60
Psychomotor Learning Outcome	Augmented Reality	Creative	87.8120	4.13454	25
		Very Creative	83.8600	2.97035	5
		Total	87.1533	4.19620	30
	PowerPoint Slide	Fair creative	82.9600	4.21151	15
		Creative	86.2533	3.97903	15
		Total	84.6067	4.36016	30
	Total	Fair creative	82.9600	4.21151	15
		Creative	87.2275	4.09722	40
		Very Creative	83.8600	2.97035	5
		Total	85.8800	4.43261	60

Table 15. Descriptive Statistics

4.2. Multivariate Analysis Result

Before calculating MANOVA, it is necessary to test variance, which is carried out in two stages: 1). The variance of each dependent variable; 2). Variance test of population Overall. The first stage is used to test the following hypotheses: H_0 = the two population variances are identical, H_1 = the two population variances are not identical. Testing is carried out using the Levene test, as shown in Table 16. The test results show that the probability value of the two variances of each dependent variable is more significant than 0.05. Therefore, H_0 is accepted; that is, the two population variances are identical.

Then in the second stage, namely the overall population variance test. This stage is used to test the following hypotheses: H_0 = the variance/covariance matrix of the dependent variable in the groups is the same, H_1 = the variance/covariance matrix of the dependent variable in the groups is not the same.

Testing at this stage is carried out using Box's M. Table 17 shows that the probability value of Box's M is 0.670. Because the probability value is more significant than 0.05, H_0 is accepted, and variance/covariance is the same. Therefore next step can continue the MANOVA process.

	F	df1	df2	Sig.
Cognitive Learning Outcome	0.493	3	56	0.689
Psychomotor Learning Outcome	0.245	3	56	0.865

Table 16. Levene's Test of Equality of Error Variances

Box's M	F	df1	df2	Sig.
7.470	0.742	9	1716.181	0.670

Table 17. Box's Test of Equality of Covariance Matrices

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Intercept	0.003	10585.251	2.000	55.000	0.000	0.997	21170.503	1.000
Learning_Media	0.864	4.338	2.000	55.000	0.018	0.136	8.676	0.730
Creative_Thinking	0.794	3.369	4.000	110.000	0.012	0.109	13.475	0.834
Learning_Media* Creative_Thinking	1.000	.	0.000	55.500	.	.	.	.

Table 18. Multivariate Tests with Wilks' Lambda

Table 18 shows that running SPSS supplies us with the impact of the MANOVA for evaluating the null hypothesis. This multivariate test uses the Wilk Lambda type, so on Learning Media, it can be seen that the significant number is 0.018, and the significant number of Creative Thinking is 0.012. The two significant values are below 0.05, so the multivariate test showed that each Independent Variable (Learning Media and Creative Thinking affected the Dependent Variable (Cognitive Learning Outcomes and Psychomotor Learning Outcomes).

The corrected model shows that the effect of all independent variables (learning media and Creative thinking) and the dependent variables (Cognitive and Psychomotor Learning Outcomes) are significant. Because of the significance value (sig) < 0.05, the model can be said to be valid. Meanwhile, the Intercept shows that the change in the value of the dependent variable (cognitive learning outcome and psychomotor learning outcome) without being influenced by the presence of the independent variable (learning media and creative thinking) is significant. It means that without the influence of the independent variable, the dependent variable can change its value. It is because of the significance value (sig) < 0.05. Table 19 shows that learning media significantly influences cognitive learning outcomes because the probability value is 0.007 or less than 0.05. While learning media does not have a significant effect on psychomotor learning outcomes because the probability value is 0.243 or greater than the value of 0.05. Table 19 shows that Creative thinking significantly influences psychomotor learning outcomes because the probability value is 0.016 or less than 0.05. At the same time, creative thinking does not significantly affect cognitive learning outcomes because the probability value is 0.116 or greater than the value of 0.05.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Corrected Model	Cognitive Learning Outcome	712.756[a]	3	237.585	7.828	.000	.295	23.484	.985
	Psychomotor Learning Outcome	243.704[b]	3	81.235	4.969	.004	.210	14.907	.894
Intercept	Cognitive Learning Outcome	227153.053	1	227153.053	7484.328	.000	.993	7484.328	1.000
	Psychomotor Learning Outcome	254754.523	1	254754.523	15582.478	.000	.996	15582.478	1.000
Learning_Media	Cognitive Learning Outcome	239.528	1	239.528	7.892	.007	.124	7.892	.788

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
	Psychomotor Learning Outcome	22.776	1	22.776	1.393	.243	.024	1.393	.213
Creative_Thinking	Cognitive Learning Outcome	136.156	2	68.078	2.243	.116	.074	4.486	.438
	Psychomotor Learning Outcome	146.422	2	73.211	4.478	.016	.138	8.956	.744
Learning_Media * Creative_Thinking	Cognitive Learning Outcome	.000	0				.000	.000	
	Psychomotor Learning Outcome	.000	0				.000	.000	
Error	Cognitive Learning Outcome	1699.628	56	30.350					
	Psychomotor Learning Outcome	915.532	56	16.349					
Total	Cognitive Learning Outcome	376082.800	60						
	Psychomotor Learning Outcome	443681.700	60						
Corrected Total	Cognitive Learning Outcome	2412.383	59						
	Psychomotor Learning Outcome	1159.236	59						

Table 19. Tests of between-subjects effect

5. Discussion

Augmented Reality provides more significant cognitive learning outcomes than PowerPoint. Augmented Reality has attractiveness and can involve students directly in learning. Augmented Reality supports being used in scientific learning and is practiced directly. This is in line with research by Weng, Otanga, Christianto and Chu (2020) state that Augmented Reality media can improve students' learning outcomes on the cognitive understanding of biology subject matter. The attractiveness and interactivity factors of Augmented Reality become an attraction for students in studying a learning material for an enhanced learning system. Augmented Reality can conduct experiments in the laboratory and also interactively investigate kinds of scientific phenomena (Jiang, Tatar, Huang, Sung & Xie, 2021). Teng, Chen and Chen (2018) state that Augmented Reality can improve learning efficiency for students in learning computer programming. Also supported by Chen (2019), Augmented Reality media is a valuable instructional tool in enhancing factors such as higher confidence, satisfaction, and lower anxiety because it provides users with usefulness, playfulness, ease of use, and engaging visual experiences. The ease of Augmented Reality as a learning medium can also increase student motivation to affect their learning outcomes (Tomara & Gouscos, 2019).

Several studies state that creative thinking affects cognitive learning outcomes. As shown by Yang and Zhao (2021) state that creative thinking influences cognitive learning outcomes and affects students'

self-esteem and controls internal locus and cognitive learning outcomes. Also supported by Akpur (2020) states that creative thinking has a positive and significant way toward predicted academic achievement positively and significantly.

However, some studies support this research, stating that creative thinking significantly affects psychomotor learning outcomes. Research on the engineering design creativity of eighth-grade students shows that creative thinking has positive correlations with psychomotor skills (Huang et al., 2020). The study by Arpan, Sulistiyarini and Santoso (2016) related to web programming points out that creativity has a positive and significant effect on students' psychomotor abilities. Also supported by Honzíková and Krotký (2017) state that the output of creative products that are advantageous community is on psychomotor skills.

6. Conclusions

The research implications on computer assembly materials for vocational students show that the average cognitive learning outcomes of students who use Augmented Reality media are higher than those who use Power Point media. Similarly, the average psychomotor learning outcomes of students who use AR media are higher than students who use Power Point media. The results of statistical calculations using MANOVA show that the use of learning media only significantly affects cognitive learning outcomes and has no significant effect on psychomotor learning outcomes. Furthermore, the results of the MANOVA calculation also show that creative thinking only has a significant effect on psychomotor learning outcomes and has no significant effect on cognitive learning outcomes. The research limitation is that the level of creative thinking is not involved in the intervention. The level of creative thinking is only measured after the learning process. Further research will engage the level of creative thinking as an intervention in the learning process.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

Akpur, U. (2020). Critical, Reflective, Creative Thinking and Their Reflections on Academic Achievement. *Thinking Skills and Creativity,* 37, 100683. https://doi.org/10.1016/j.tsc.2020.100683

Alkhamisi, A.O., & Monowar, M.M. (2013). Rise of Augmented Reality: Current and Future Application Areas. *International Journal of Internet and Distributed Systems,* 01(04), 25-34. https://doi.org/10.4236/ijids.2013.14005

Arpan, M., Sulistiyarini, D., & Santoso, D. (2016). Effect of motivation and creativity on students' psychomotor abitlity. *JETL (Journal Of Education, Teaching and Learning),* 1(2), 71. https://doi.org/10.26737/jetl.v1i2.42

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent Advances in Augmented Reality. *IEEE Computer Graphics and Applications,* 21(6), 34-47. https://doi.org/10.1109/38.963459

Çakır, R., Korkmaz, Ö., İdil, Ö., & Erdoğmuş, F. U. (2021). The Effect of Robotic Coding Education on Preschoolers' Problem Solving and Creative Thinking Skills. *Thinking Skills and Creativity,* 40, 100812. https://doi.org/10.1016/j.tsc.2021.100812

Carvalho, C.V.A., & Morais-Lemos, B. (2014). Possibilities of Augmented Reality Use in Mathematics Aiming at a Meaningful Learning. *Creative Education,* 05(09), 690-700. https://doi.org/10.4236/ce.2014.59081

Chang, Y.J., Kang, Y.S., & Huang, P.C. (2013). An Augmented Reality (AR)-Based Vocational Task Prompting System for People with Cognitive Impairments. *Research in Developmental Disabilities,* 34(10), 3049-3056. https://doi.org/10.1016/j.ridd.2013.06.026

Chen, Y.C. (2019). Effect of Mobile Augmented Reality on Learning Performance, Motivation, and Math Anxiety in a Math Course. *Journal of Educational Computing Research,* 57(7), 1695-1722. https://doi.org/10.1177/0735633119854036

Chiang, T.H.C., Yang, S.J.H., & Hwang, G.J. (2014). Students' Online Interactive Patterns in Augmented Reality-Based Inquiry Activities. *Computers & Education,* 78, 97-108. https://doi.org/10.1016/j.compedu.2014.05.006

Efrén-Mora, L.C., Carrau-Mellado, R., & Añorbe-Díaz, B. (2013). PBL Methodologies with Embedded Augmented Reality in Higher Maritime Education: Augmented Project Definitions for Chemistry Practices. *Procedia Computer Science,* 25, 402-405. https://doi.org/10.1016/j.procs.2013.11.050

Fombona-Cadavieco, J., Goulão, M.F., & Fernandez-Costales, A. (2012). Using Augmented Reality and M-Learning to Optimize Students Performance in Higher Education. *Procedia - Social and Behavioral Sciences,* 46, 2970-2977. https://doi.org/10.1016/j.sbspro.2012.05.599

Gajda, A. (2016). The Relationship between School Achievement and Creativity at Different Educational Stages. *Thinking Skills and Creativity,* 19, 246-259. https://doi.org/10.1016/j.tsc.2015.12.004

Heilman, K.M. (2005). *Creativity and the Brain*. Psychology Press. https://doi.org/10.4324/9780203942895

Honzíková, J., & Krotký, J. (2017). Correlation between Psychomotor Skills and Creativity among Secondary School Students and Future Teachers. *Edukacja – Technika – Informatyka,* 20(2), 93-101. https://doi.org/10.15584/eti.2017.2.11

Hsu, Y.S., Lin, Y.H., & Yang, B. (2017). Impact of Augmented Reality Lessons on Students' STEM Interest. *Research and Practice in Technology Enhanced Learning,* 12(1), 2. https://doi.org/10.1186/s41039-016-0039-z

Hu, W., & Adey, P. (2002). A Scientific Creativity Test for Secondary School Students. *International Journal of Science Education,* 24(4), 389-403. https://doi.org/10.1080/09500690110098912

Huang, N.T, Chang, Y.S., & Chou, C.H. (2020). Effects of Creative Thinking, Psychomotor Skills, and Creative Self-Efficacy on Engineering Design Creativity. *Thinking Skills and Creativity,* 37, 100695. https://doi.org/10.1016/j.tsc.2020.100695

Jiang, S., Tatar, C., Huang, X., Sung, S., & Xie, C. (2021). Augmented Reality in Science Laboratories: Investigating High School Students' Navigation Patterns and Their Effects on Learning Performance. *Journal of Educational Computing Research,* 073563312110387. https://doi.org/10.1177/07356331211038764

Ke, F., & Hsu, Y.H. (2015). Mobile Augmented-Reality Artifact Creation as a Component of Mobile Computer-Supported Collaborative Learning. *The Internet and Higher Education,* 26, 33-41. https://doi.org/10.1016/j.iheduc.2015.04.003

Lin, Y.S. (2011). Fostering Creativity through Education – A Conceptual Framework of Creative Pedagogy. *Creative Education,* 02(03), 149-155. https://doi.org/10.4236/ce.2011.23021

Majid, N.A.A., Mohammed, H., & Sulaiman, R. (2015). Students' Perception of Mobile Augmented Reality Applications in Learning Computer Organization. *Procedia - Social and Behavioral Sciences,* 176, 111-116. https://doi.org/10.1016/j.sbspro.2015.01.450

O'Reilly, C.J. (2016). Creative Engineers: Is Abductive Reasoning Encouraged Enough in Degree Project Work? *Procedia CIRP,* 50, 547-552. https://doi.org/10.1016/j.procir.2016.04.155

Onime, C., & Abiona, O. (2016). 3D Mobile Augmented Reality Interface for Laboratory Experiments. *International Journal of Communications, Network and System Sciences,* 09(04), 67-76. https://doi.org/10.4236/ijcns.2016.94006

Runco, M.A., Millar, G., Acar, S., & Cramond, B. (2010). Torrance Tests of Creative Thinking as Predictors of Personal and Public Achievement: A Fifty-Year Follow-Up. *Creativity Research Journal,* 22(4), 361-368. https://doi.org/10.1080/10400419.2010.523393

Siswono, T.Y.E. (2011). Level of Student's Creative Thinking in Classroom Mathematics. *Educational Research and Review,* 6(7), 548-553. https://doi.org/10.5897/ERR.9000226

Teng, C.H., Chen, J.Y., & Chen, Z.H. (2018). Impact of Augmented Reality on Programming Language Learning: Efficiency and Perception. *Journal of Educational Computing Research,* 56(2), 254-271. https://doi.org/10.1177/0735633117706109

Tomara, M., & Gouscos. D. (2019). A Case Study: Visualizing Coulomb Forces With the Aid of Augmented Reality. *Journal of Educational Computing Research,* 57(7), 1626-1642. https://doi.org/10.1177/0735633119854023

Torrance, E.P. (1968). A Longitudinal Examination of the Fourth Grade Slump in Creativity. *Gifted Child Quarterly,* 12(4), 195-199. https://doi.org/10.1177/001698626801200401

Tsai, C.H., & Yen, J.C. (2014). The Augmented Reality Application of Multimedia Technology in Aquatic Organisms Instruction. *Journal of Software Engineering and Applications,* 07(09), 745-755. https://doi.org/10.4236/jsea.2014.79069

Weng, C., Otanga, S., Christianto, S.M., Chu, R.J.C. (2020). Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement. *Journal of Educational Computing Research.* 58(4), 747-770. https://doi.org/10.1177/0735633119884213

Yang, J., & Zhao, X. (2021). The Effect of Creative Thinking on Academic Performance: Mechanisms, Heterogeneity, and Implication. *Thinking Skills and Creativity,* 40, 100831. https://doi.org/10.1016/j.tsc.2021.100831

Yildiz, C., & Yildiz, T.G. (2021). Exploring the Relationship between Creative Thinking and Scientific Process Skills of Preschool Children. *Thinking Skills and Creativity,* 39, 100795. https://doi.org/10.1016/j.tsc.2021.100795

Zheng, S. (2015). Research on Mobile Learning Based on Augmented Reality. *Open Journal of Social Sciences,* 03(12), 179-182. https://doi.org/10.4236/jss.2015.312019

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Journal of Technology and Science Education, 2023 (www.jotse.org)