

*Research Article***Augmented Reality for teaching science: Students' problem solving skill, motivation, and learning outcomes**Fitriana Nur Astuti <sup>a,1,\*</sup>, Suranto <sup>b,2</sup>, Mohammad Masykuri <sup>c,3</sup><sup>a</sup> Graduate Program of Science Education, Universitas Sebelas Maret, Jl. Ir. Sutami No.36A Surakarta 57126, Indonesia<sup>b</sup> Department of Biology, Faculty of Mathematic and Sciences, Universitas Sebelas Maret, Jl. Ir. Sutami No.36A Surakarta 57126, Indonesia<sup>c</sup> Department of Science Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl. Ir. Sutami No.36A Surakarta 57126, Indonesia<sup>1</sup> fitriananurastuti@gmail.com\*; <sup>2</sup> surantoak@staff.ac.id; <sup>3</sup> mmasykuri@staff.ac.id

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## ABSTRACT

Besides learning outcomes, motivation and problem solving skill are the essential indicators for successful learning. Hence, the existence of learning media which considerably follow the advance of technology has been assumed to be able to support the achievement of the indicators mentioned. Thus, the current research aimed at implementing the Augmented Reality (AR) technology to improve students' problem solving skill, motivation, and learning outcomes. The sample was 56 of eighth graders which covered the both control and experimental classes. This quasi experimental research employed test and observation sheet as the instruments. The data was analyzed using one-way analysis of covariance (ANCOVA). The ANCOVA test results showed that were significance differences of the three indicators (problem solving skills, motivation, and learning outcomes) achieved, in which the experimental class was higher than control class. In conclusion, the AR can influence students' problem solving skills, motivation, and learning outcomes.



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**INTRODUCTION**

Motivation and learning are two things that influence each other (Afzal, Ali, Khan, & Hamid, 2010; Lai, 2011; Saeed & Zyngier, 2012; Uno, 2014; Vibulphol, 2016). Motivation plays an important role in strengthening learning when the student has faced problems. According to Tohidi and Jabbari (2012), the definition of motivation is "turn on people to achieve high levels of performance and overcome obstacles to change". Motivation is guidance, control, and perseverance in human behavior. Things that strengthen a person's behavior, guide behavior or behavior in a certain direction, improve or maintain his behavior (Ferreira, Cardoso, & Luís Abrantes, 2011; Lai, 2011). Regarding the importance of motivation, research shows that student with high work motivation shows a greater commitment to their work (Buijs & Admiraal, 2013; Taurina, 2015), such as in science learning.

However, the observation result in some junior high schools in Indonesia, there are some difficulties experienced by students in science learning. Based on the observation, the teacher did not use active, creative,

innovative, effective, and fun learning methods and models that make students become interested and not bored in learning. Therefore, lack of student motivation in the learning process will emerge. If there is no motivation, the activities carried out will not achieve maximum results and cannot even reach the learning objectives. Besides that, the students were not developing their problem-solving skills. The learning model and media were not accommodating problem-solving skill in students' learning. According to [Chiang and Lee \(2016\)](#), the students require problem-solving skill, and it can only be gained by their experience about solving the problems. This condition can be the learning reinforcement for students if they are having the motivation to learn something. On the other hand, the questionnaire result completed online by students showed that they were very interested in the possibility of interacting with program content. The use of the prototype was showing greater motivation in student to complete the tasks. During the use of the prototype, the students showed high levels of concentration for their achievements.

Furthermore, the problem of learning motivation and problem-solving skill are surely a concern in Indonesia. Based on the results of the PISA study in 2012 ([OECD, 2013](#)), Indonesia was ranked 64 of 65 participating countries. In other words, Indonesia was becoming the second-lowest ranking of all PISA participating countries surveyed, with an average score of Indonesian students' science skills is 382, the score is in below the international average score (494). The results of the PISA study in 2015 ([PISA, 2015](#)), Indonesia was ranked 66 of 72 countries with the score was 403, which was still below the international average score. The important factor is the lack of problem-solving skills in the learning process. The questions tested in PISA measure were related to reasoning skills, problem-solving skill, and argumentation. While students in Indonesia are only familiar with the low level of problem (cognitive level 1 and 2). Therefore, it can be concluded that the problem-solving skill of Indonesian students in science is low.

Problem-solving skill is one very important abilities in science learning ([Chiang & Lee, 2016](#); [Okubo et al., 2016](#); [Sagala, Rahmatsyah, & Simanjuntak, 2017](#)). Otherwise, lacking this skill can cause students having the habit of carrying out various activities without knowing the purpose and reason for doing so ([Chiang & Lee, 2016](#)). Problem-solving skill are one of the main quality parameters of someone living in a modern society, which is very technical, scientific, and complex ([Binkley et al., 2014](#)). [Simamora, Simamora, and Sinaga \(2017\)](#) explained that the importance of problem-solving for the student. The discussion revealed that problem-solving activities help students to build new scientific knowledge. Thus, the problem-solving skill was important to be developed in science learning, as well as the students' motivation.

To deal with the problems, this study will provide solutions with the use of media in the learning process. The chosen media is the media with the latest technology which has to cover four main characteristics, namely clarity of message delivery, stand-alone, user-friendly and content representative. The media employed Augmented Reality (AR) technology. As stated by [Oranç and Küntay \(2019\)](#) the development of AR learning can support the students' learning. AR technology affects the confidence of students in their problem-solving skill ([Deshpande & Kim, 2018](#); [Karagozlu, 2018](#)). The higher improvement of confidence and students' achievement was observed in the experimental group which used AR application ([Karagozlu, 2018](#)). [Ferrer-Torregrosa, Torralba, Jimenez, Garcia, and Barcia \(2015\)](#) also convey that the use of AR is suitable for anatomical purposes. Concretely, the results show how this technology helps to motivate students. This study presents a new tool experience based on augmented reality (AR) that focuses on anatomy. Another study conducted by [Markamah, Subiyanto, and Murnomo \(2018\)](#) also shows that students' performance in learning improved significantly by using AR book app media. This study indicated that the experimental group learning outcome is better than the control group ([Markamah et al., 2018](#)).

Learning by combining media technology will have a significant influence on learning achievement ([Herbert, Ens, Weerasinghe, Billingham, & Wigley, 2018](#); [Sakat et al., 2012](#)). Besides, technology can be used as an innovative learning media that is believed can keep up with the developed era ([Sakat et al., 2012](#)). The implementation of learning media ICT-based will increase the student learning motivation, as well as student learning outcomes ([Harandi, 2015](#)). As claim by [Chen, Liu, Cheng, and Huang \(2017\)](#) AR studies in education conducted from 2011 until 2016 has increased, significantly since 2013. The application of AR was showing good potential in giving students a more active, effective and meaningful learning process ([Alkhatabi, 2017](#)). Nevertheless, from some previous research, it doesn't show that AR has an impact at the same time for students' problem-solving skill, motivation, as well as learning outcomes. Hence, this study will examine whether AR has an impact on those three aspects. Therefore the study aimed to implement media with AR technology to increase learning motivation, problem-solving skills, and learning outcomes.

## METHOD

This quasi-experimental research was using eighth-graders in SMPN (*Sekolah Menengah Pertama Negeri – State Junior High School*) 1 Bungkal in Ponorogo Regency, East Java, Indonesia. There are 56 students 2017/2018 academic year which covered both control and experimental classes as research sample. The AR

media was used in experimental group, while the control group was using PowerPoint. Previously, pre-experiments have also been conducted to test the feasibility of AR media and get 85% eligibility results in the good category (Astuti, Suranto, & Masykuri, 2019). This research employed a test and observation sheet as the instruments. Test instrument used to measure students' problem-solving skill and learning outcome. While the observation sheet used to observe their learning motivation. The instrument was validated by experts. The student's problem-solving skill and learning motivation indicators are shown in Table 1.

Table 1. The measured indicators of students' problem-solving skill and motivation

No	Aspects	Indicators
1	Problem-solving skill	1. Identifying problems
		2. Formulating (analyzing) problems
		3. Finding a solution
		4. The quality of problem-solving results (evaluation)
2	Motivation	1. Enthusiastic
		2. Curiosity
		3. Passion
		4. Perseverance
		5. Confidence
		6. Persistence
		7. Independence
		8. Concentration

This quasi-experimental research was conducted in five meetings on the structure and function of plant tissue material. At the first meeting, pre-test conducted to measure students' problem-solving skill and learning outcome before using AR media (experimental group) and PowerPoint (control group). Then, the teacher and observers were observing the students' motivation when using AR media in class for four meetings. At the end of meeting post-test was conducted to measure the problem-solving skill and learning outcome after giving the treatment. The data was analyzed using gain score and one-way analysis of covariance (ANCOVA). Before conducting the ANCOVA test, homogeneity and normality test was conducted as a prerequisite test.

## RESULTS AND DISCUSSION

The result of the gain score analysis of students' motivation and problem-solving skill are stated in Table 2. Based on Table 2, it can be seen that the gain score of students' motivation in control reached 0.48 which is included in the medium category. Besides, the gain score of students' problem-solving skill is 0.24 which categorize as low level. On the other hand, the experimental group gets higher score both in students' motivation and problem-solving skill. The motivation has significant improvement seen from the gain score which reached 0.74 which is categorized as a high category. The difference result between the control and experimental group shows that AR media is very effective in increasing learning motivation and working optimally for student learning motivation. While the gain score of students' problem-solving skill in the experimental group is only 0.51 with the medium category. However, this value is still higher than the control group.

Table 2. Gain score result of students' motivation and problem-solving skill

No.	Group	Number of Students	Aspects	Average		Difference	Gain score	Category
				Pre-test	Post-test			
1	Control	28	Motivation	53.46	74.78	21.31	0.48	Medium
			Problem-solving skill	41.34	55.22	13.80	0.24	Low
2	Experimental	28	Motivation	52.23	87.39	35.16	0.74	High
			Problem-solving skill I	42.14	71.52	29.38	0.51	Medium

Furthermore, the results of the normality test presented in Table 3 which show that in the experimental group or even the control group, the significance result more than  $\alpha$  value (0.05). Thus it can be concluded that the samples in both classes are normally distributed. While Table 4 shows the result of the homogeneity test of students' problem-solving skill data. The significance result for pre-test is 0.156 ( $> 0.05$ ) and post-test is 0.171 ( $> 0.05$ ) which can be concluded that the samples from both classes have homogeneous variants between groups.

Table 3. The result of normality test of students' problem-solving skill data

Aspects	Test	Significance Degree		Result
		Control Group	Experimental Group	
Problem-solving skill	Pre-test	0.160	0.171	Normal
	Post-test	0.255	0.231	Normal

**Table 4.** The result of homogeneity test of students' problem-solving skill data

Aspects	Test	Significance Degree	Result
Problem-solving skill II	Pre-test	0.156	Homogeneous
	Post-test	0.171	Homogeneous

Moreover, the ANCOVA result (Table 5) showed that  $p\text{-value} < \alpha$  (0.05), thus it can be concluded that there is a significant influence of AR media towards students' problem-solving skill. Besides, the students' learning outcomes also examined in this research which is presented in Table 6. Based on Table 6, the students' learning outcomes in the experimental group are higher than the control group. From the 3 aspects of all learning outcomes showed that the experimental group was more superior than the control group. A very significant comparison is on the knowledge aspect. The average value aspect of the control group knowledge is only 70.65 while in the experimental group it reaches 80.06. Whereas in the other two aspects, attitudes and skills have not too much difference.

**Table 5.** The result of ANCOVA of students' problem-solving skill

Aspects	Significance Degree	Result
Problem-solving skill	0.000	There are significant differences

**Table 6.** The result of learning outcomes in experimental and control group

No	Group	Number of Students	Learning Outcomes		
			Attitude	Knowledge	Skill
1	Experimental	28	78.14	80.06	80.25
2	Control	28	74.25	70.65	74.17

Based on Table 5, showed that the AR media give an impact on students' problem-solving skill. The student can explore the material by themselves using the AR media. This media also makes student practice to solve the problem. As stated by Crofton, Botinestean, Fenelon, and Gallagher (2019) AR is very useful for interactive and real learning media for students. By utilizing AR media can increase the interest of students in learning because of the AR that combines cyberspace that can increase the imagination of students with the real world directly (Berryman, 2012; Bower, Howe, McCredie, Robinson, & Grover, 2014; Oranç & Küntay, 2019; Turan, Meral, & Sahin, 2018). AR is interactive which allows students to see the situation in a real and direct way and can imagine the results of the learning process provided by teachers to students. The use of educational media using AR can stimulate the mindset of students in thinking critically about problem and events that occur on daily life because learning media is helping students in the learning process with the presence or absence of teachers in the education process (Sonntag, Albuquerque, Magnor, & Bodensiek, 2019). So that media use education with augmented reality can directly provide learning wherever and whenever students want to carry out the learning process (Carrera & Asensio, 2017; Sonntag et al., 2019; Turan et al., 2018). Previous research states that using AR applications positively influences self-confidence in students' problem-solving skills (Karagozlu, 2018). Based on Table 2, the gain score of the experimental group is higher than the control group. It's mean AR that used as a media in the experimental group is effective to increase the problem-solving skill. Effectiveness of learning media are used to improve students' skills to solve problems, it is necessary to develop learning media that reflect problem-solving steps (Widodo, Darhim, & Ikhwanudin, 2018). So that students indirectly feel guided in solving the problems faced by them.

Further, the impact of AR media for motivation is shown in Table 2. The gain score of experimental group is higher than the control group, it is shown that AR media is very effective in increasing learning motivation and working optimally for student learning motivation. According to Khan, Johnston, and Ophoff (2019) AR media can involve students and motivate them to explore in the context of immersion between teaching materials from the real world with virtual objects created by AR technology. The results of previous studies also showed that immersion and interactivity factors were two predictors for student motivation (Huang & Liaw, 2014; Iftene & Trandabăţ, 2018; Khan et al., 2019; Lee, 2012; Sonntag et al., 2019). The results of the study show that learning motivation is a predictor for students' intentions to use the AR learning system (Lee, 2012). AR system can provide motivation, entertainment, and an attractive environment that is conducive to learning (Iftene & Trandabăţ, 2018; Sampaio & Almeida, 2018). Other research also mentions if series of studies provide evidence of increased academic performance, increased involvement, motivation, and student satisfaction through an educational environment enriched with AR applications (Saltan & Arslan, 2017). AR technology can offer opportunities to create a user-friendly and immersion learning environment that can be a useful environment for learning (Huang & Liaw, 2014). The mobile augmented reality application increases student learning motivation

(Khan et al., 2019). Attention, satisfaction, and motivational confidence factors increase, and these results are found to be significant (Huang & Liaw, 2014; Khan et al., 2019; Mahadzir & Phung, 2013; Sonntag et al., 2019).

As well as problem-solving skill and motivation, the students' learning outcome also influence by AR media (Table 6). The three aspects of learning outcomes (attitude, knowledge, and skill) in the experimental group are higher than the control group. Whereas in the two domain (attitude and skill) have not too much difference. According to Lindner, Rienow, and Jürgens (2019) AR media can easily visualize what's happening and easily understand the complex concepts so that they can facilitate and improve the learning process and learning outcomes. This technology is effective to help the student understand the concept (Fakhrudin, Sri, & Riyadi, 2019; Ibáñez & Delgado-Kloos, 2018; Markamah et al., 2018; Petersen & Stricker, 2015; Purnamasari, Suciati, & Dwiastuti, 2016; Yuliono, Sarwanto, & Rintayati, 2018). AR is the technology that can help explain in some subjects that require 3D visualization, especially on material that requires a lot of 3D visualization (Carrera & Asensio, 2017; Chien, Chen, & Jeng, 2010; Vate-U-Lan, 2012). AR media can visualize abstract concepts for understanding and structure of an object model (Carrera & Asensio, 2017; Chien et al., 2010; Kurniawan, Suharjito, Diana, & Witjaksono, 2018; Lindner et al., 2019; Mustaqim, 2016). Besides, Pemberton and Winter (2009) examined the use of AR technology in the school environment on various subjects. The result showed that AR technology suitable for certain subjects that require visualization to model an object. Another advantage of using Augmented Reality technology-based learning media is that students can study independently outside the classroom without the need for additional costs for the procurement of tools (Crofton et al., 2019; Sonntag et al., 2019; Vate-U-Lan, 2012). With a little guidance, students can operate AR technology well (Iftene & Trandabăț, 2018). AR technology makes it easy for students to think in real terms without bringing in their practical tools directly by displaying 3D animation of electronic components that resemble their original form.

## CONCLUSION

The result of this study showed that the use of Augmented Reality (AR) media is effective for increasing students' learning motivation, problem-solving skill and learning outcomes. From ANCOVA test showed that the p-value <  $\alpha$  (0.05), thus there is significant influence of AR towards students' problem-solving skill. It is recommended to use AR media on an ongoing basis for other science materials, because it has a positive impact on students problem-solving skill, motivation, and learning outcomes. In addition, other research can be done to determine the effectiveness of media augmented reality on the other students' skills or competencies.

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