The effect of augmented reality application (ARSINAPS) on learning motivation and outcomes in biology

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ABSTRACT

This study aims to determine the effectiveness of using the ARSINAPS mobile augmented reality application on learning motivation and outcomes in high school and biology education students. The method used in this study was quasi-experimental with a post-test control group design. The research sample consisted of two experimental classes and two control classes from three schools in the Jakarta, Bekasi, and Tangerang areas, totalling 140 students, and from the college level, consisting of one experimental class and one control class, totalling 68 students. The data obtained were in the form of learning outcomes in the respiratory system and learning motivation scores in biology learning. The average high school-level motivation score in the control class was 85.99, and the overall average for learning outcomes was 77.33 and 63.05. Based on the results of the data calculations, the application effectively improves students' learning outcomes at the high school and undergraduate levels.

INTRODUCTION

Learning is a part of life and the main activity carried out by students. However, not all students enjoy the learning process. Lots of learning content, thick learning books with lots of text content can make students not enjoy the learning process and need more motivation to learn. One approach can be a solution, namely authentic learning, which is a learning approach that can encourage students in actual activities to learn about specific skills (Liono et al., 2021). In line with this, the rapid development of technology, which is then integrated into its use in content and learning processes, has a good influence on learning outcomes and motivation.

Augmented reality (AR) is a technology that can provide a 3D depiction of an object which can also be equipped with audio and video. Mobile augmented reality is AR that can be accessed using a mobile device. Augmented reality is a technology that can improve user perception and interaction with the real world (Azuma, 1999; Thomas, 2007). Augmented reality has three characteristics: combining virtual content with actual content, having an interactive system that can be used in real time, and adding virtual content to the real world. In several previous studies, AR is a technology that can be used broadly, including in Education, Health, Engineering, Military, and Entertainment areas (Thomas, 2007).

AR technology in teaching and education has been widely developed in developed countries. AR collaboration in learning mathematics and geometry with constructing Construct3D can improve students' spatial thinking skills in Austria (Kaufmann, 2003). AR has also been developed in science learning in order to increase understanding through visualization of 3D objects (Hurst, 2020), in chemistry for the introduction of chemical sources (Nechypurenko et al., 2018), and in biology learning in Malaysia with the development of the ATTech System (Weng et al., 2017).

The advantages of using Augmented reality in learning can be divided into three categories, namely in terms of learning outcomes, pedagogical contributions, and interactions. AR can increase students' positive attitudes toward learning activities, improve learning achievement and learning performance, and can increase student satisfaction with the learning process (Akçayır & Akçayır, 2017; Chen & Tsai, 2012; Chiang et al., 2014; Lu & Liu, 2015; Muñoz-Cristóbal et al., 2015). AR contributes to increasing student involvement and attachment to the learning process and makes learning more fun (Akçayır & Akçayır, 2017; Lu & Liu, 2015).

Augmented Reality (AR) technology in the learning process has been shown to increase motivation and assist students in observing learning material objects that are difficult for the eye to see (Akçayır & Akçayır, 2017; Wu et al., 2013). AR media can help students to learn better about specific materials. AR media can help students due to the ability of AR media to visualize abstract concepts into 3D objects. Furthermore, students think AR media is exciting and motivates them to learn (Liono et al., 2021). AR in biology learning can be used to make it easy for students to understand the material that is abstract and difficult to observe.

Biology learning, which is full of observations of microscopic objects, can be easily visualized in 3D using AR. Visual illustrations increase student activity and motivation and pave the way for learning other than text-based knowledge (Erbas & Demirer, 2019). Several studies regarding the use of AR in learning state that AR influences academic achievement in several content areas, including biology (Jamali, 2017). Several studies have also shown that AR positively affects motivation in different groups of students in learning biology (Chien et al., 2019; Safadel & White, 2019).

The use of AR in teaching contributes to increasing enjoyment of learning and increasing student involvement in learning activities because the 3D object features provided in AR applications are attractive so that they can warm up the learning atmosphere (Lu & Liu, 2015). AR can also facilitate hybrid or blended learning by combining digital environments with real physical objects. The use of AR also provides advantages in increasing interaction between students and also an interaction between teachers and students (Akçayır & Akçayır, 2017). In another study, AR has proven to be very useful in helping students with a visual learning style because it helps them visualize abstract concepts or phenomena that are difficult to observe (Wu et al., 2013).

Based on data from Google Trends, the trend of research on augmented reality in Indonesia looks stable in the last five years, with the number of articles published on this topic an average of 43 articles each year. From 2019 to 2021, there has been an increasing trend of research on using AR for all areas of life, one of which is education. AR technology development in biology learning has also been carried out a lot. This momentum is used to continue innovating and developing other AR applications in biology

material, followed by a comprehensive evaluation and effectiveness testing process to produce practical applications.

In previous research, an augmented reality mobile application based on the Android system was developed on the material of the respiratory system with the name ARSINAPS (Rini et al., 2022). The advantage of this AR application that has been developed is the zoom-in and zoom-out feature, which can provide a structured visualization of the constituent tissues of the organs in the respiratory system. This feature aims to increase understanding of the relationship between the structure of organ-composing tissues and their function in the body's bioprocesses. A good understanding of the concept influences learning outcomes and motivation.

Motivation and learning outcomes are two things that are always closely related to the student learning process. Student motivation can rise and fall depending on the learning process obtained. The learning process in schools in the current 4.0 era, with the rapid development of information and technology and high demands for competency, requires greater motivation from students to participate in learning well. Thus, many innovations in instructional design, learning resources, and learning media have been carried out, including AR media, which is considered capable of motivating students to learn. Learning outcomes are related to the learning process, including declines and increases, which are influenced by many factors, one of which is a fun learning process with suitable media.This application has undergone an expert validation process and evaluated the satisfaction of using the application with good results. Testing the effectiveness of using the application is needed as a follow-up to evaluating the products that have been produced so that they are accurate and proven effective in improving learning outcomes in biology learning, namely motivation and learning outcomes. Therefore, this study aims to determine the effectiveness of using the ARSINAPS mobile augmented reality application on learning motivation and outcomes in high school and biology education students.

METHODS
Research Design
The method used in this study was quasi-experimental with a post-test control group design. The research subjects included grade 11 of high school students and first-year biology education students who have taken general biology course. The research sample at the high school level consisted of two experimental classes and two control classes from three schools in the Jakarta, Bekasi, and Tangerang areas, totalling 140 people. The sample from biology education department from Universitas Negeri Jakarta consisted of one experimental class and one control class with 34 students respectively.

Population and Samples
This research focus on grade 11 high school students and first-year students from biology education department in Higher Education in Jakarta, Bogor, Depok, Tangerang, and Bekasi area. The sample of high school students came from 3 schools, each from the Jakarta, Bekasi, and Tangerang areas, and was taken using the cluster random sampling technique. The total Respondents were 180 students from 2 control and 2 experimental classes, 140 students were taken as a sample using a random sampling technique. So that there are 30 sample students in each class. The research sample from the college level from Biology Education program Universitas Negeri Jakarta consisted of one experimental class and one control class. Each class for students consists of 34 sample people, so the total research sample from the tertiary level was 68 people taken by using simple random sampling technique.

Instrument
The research data obtained were in the form of learning outcomes in Biology Subject especially on the respiratory system and learning motivation scores in biology learning. The motivational questionnaire uses the learning motivation questionnaire by Tuan (2015) using a Likert scale of 1-5 (strongly disagree – strongly agree) with a total of 35 item statements which consists of 9 negative items and 26 positive items. The instrument has been validated and tested with 23 valid statements. Testing the reliability of the items using the Cronbach's Alpha test obtained a test result of 0.708 (high reliability). The Motivational Instrument Grid can be seen in Table 1.

Tabel 1.
Motivational Instrument Grid

Nu	Indicators	Negative Items	Positive Items	Total (items)
1	Self-efficacy	2*, 5, 6, 7	1*, 3*, 4	7
2	Active Learning Strategy	-	8, 9, 10, 11, 12, 13*, 14, 15	8
3	Learning Value	-	16, 17, 18, 19*, 20	5
4	Performance Goal	21*, 22*, 23, 24*	-	4
5	Achievement Goal		25, 26*, 27, 28, 29	5
6	Learning Environment Stimulation		30, 31, 32*, 33*, 34, 35*	6
	Total			35

Note: *invalid item

Procedure

The research was conducted within 6 months. Research activities began with the design of learning activities and initial observations. While learning the respiratory system material, the experimental class used the Respiratory System Augmented Reality learning media (ARSINAP), supported by other media commonly used by the teacher. In contrast, the control class will be given learning materials for the respiratory system without using ARSINAP media. Both the experimental class and the control class apply the same learning model. After learning has lasted for 3 meetings, each class will be given a knowledge test about the respiratory system, and the results will be used as learning outcome data. In addition, students were also given a motivational questionnaire at the end of the research period. Research activities at tertiary institutions also took place similarly; the experimental class used additional ARSINAP media, while the control class did not. Knowledge tests regarding the respiratory system and motivation tests were given to students after 2 lecture meetings were completed. Data on learning outcomes and motivation obtained are then processed and tested according to predetermined hypotheses.
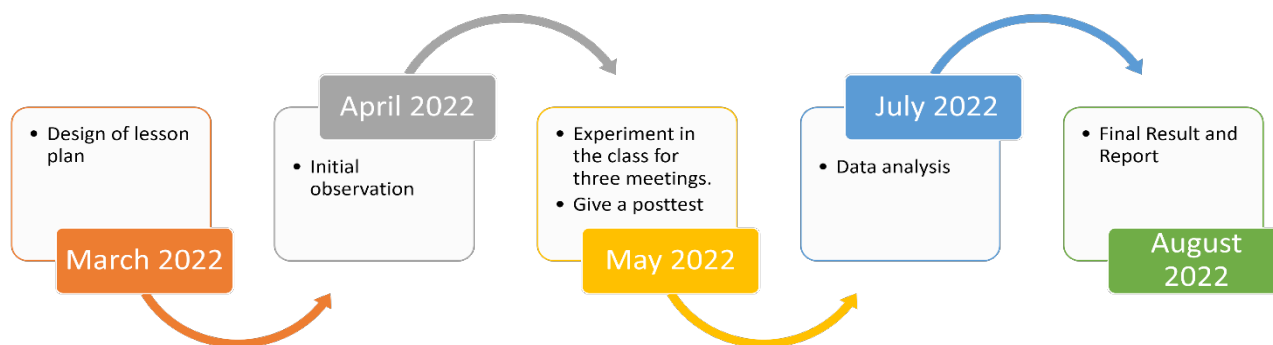

Figure 1. Research Timeline

Data Analysis Techniques

Analysis of the data obtained uses a statistical test with a t-test after going through the Normality test using the Kolmogorov-Smirnov Test and Homogeneity (F-Test) as a prerequisite test. Data was tested using a significance level of 0.05. The results of the normality test show that the data is normally distributed (sig (0.1) > α (0.05)) and homogeneous. The data analysis process uses SPSS ver.27 software.

RESULTS AND DISCUSSION

Based on the results of descriptive data calculations, the average high school-level motivation score in the control class was 85.60, and in the experimental class was 85.99. The results of learning biology at the high school level for the control class was 55.20, and the experimental class was 74.84. Meanwhile, at the undergraduate level, the score for learning outcomes was higher, namely in the control class 79.2 and the experimental class 82.43. The motivation variable was not tested at the undergraduate level and is a limitation in this study. A comparison of motivation scores and learning outcomes from the two levels in each class can also be seen in the Table 2.

Table 2.
Descriptive Calculation Results

	Level of Education			
	Highschool		Undergraduate	
	Means	**Std.Dev**	**Means**	**Std.Dev**
Motivation				
Control Group	85.60	8.04	-	-
Experiment Group	85.99	7.57	-	-
Means of Learning Outcome				
Control Group	55.20	27.32	79.2	9,93
Experiment Group	74.84	21.19	82.43	3,85

Based on the results of the prerequisite test, it is known that all data are typically distributed and also homogeneous at a significance level of 0.05. The hypothesis test was carried out to see if there was a difference between the experimental class, which was given treatment using ARSINAP as a learning medium, and the control class, which did not use ARSINAP at both the high-school and undergraduate levels. Based on the results of data analysis (Table 3), it was found that the variable motivation at the high school level did not have a significant difference between the experimental and control classes (sig = 0.739 > 0.05) These results show that using ARSINAPS learning media does not have a practical impact on increasing student motivation.

Table 3.
Motivation Variable T-test

	t	df	Sig (2-tailed)	Mean Difference	Std. error Difference
Motivation	0.292	138	0.771	0.386	1.320
	0.393	137.483	0.771	0.386	1.320

Subsequent tests were carried out on learning outcome variables at both levels of education. The overall average for learning outcomes in the experimental class was 77.33, and in the control class was 63.05. The results of the t-test for this data indicate a difference between the values in the experimental and control classes at both levels of education (sig = 0.01 <0.05). These results indicate that the ARSINAPS learning media effectively improves students' biology learning outcomes at the high-school and undergraduate levels. The learning outcomes of the experimental class using ARSINAPS media have better scores than the control class which does not use ARSINAPS learning media. Detailed results of hypothesis testing can be seen in the following table,

Table 4.
Learning Outcome Variable T-test

	t	df	Sig (2-tailed)	Mean Difference	Std. error Difference
Learning Outcome	4.659	206	.000	14.279	3.065
	4.659	183.646	.000	14.279	3.065

Based on the results of the hypothesis testing that has been done, it is found that the ARSINAPS application effectively increases student learning outcomes both at the high school level and the undergraduate level. The advantages of AR media with three-dimensional objects help students visualize biological objects that are difficult to observe directly, especially for the organs that make up the human body system. AR provides easy access for students to learn things or phenomena that are difficult to observe, such as the sun's movement and how magnetic fields work with a simulation system in the classroom (Cai et al., 2017; Tarng et al., 2018). AR as a learning medium can enrich the process and experience of learning activities in the classroom (De Paolis & Mongelli, 2016).

ARSINAPS is an application developed considering the needs of learning target achievements in the essential competencies of high school students; in this case, the essential competencies targeted are students who can understand the relationship between organ structure and function in the bioprocess of the respiratory system in humans. The three-dimensional objects presented in this application consist

of complete and complete organ and respiratory tract objects, namely the pharynx, larynx, throat, bronchi, bronchioles, and lungs. In each part of the organ, with the help of zoom-in and zoom-out, features can be detailed more about the structure of the constituent tissues. With these features, students can build their concept of knowledge about the structure of the organ-composing tissue in each respiratory organ. It is equipped with a three-dimensional visualization of the shape of the composing tissue in each of these organs. This feature allows students to systematically construct their knowledge concepts to understand better the material being studied. Thus, the learning outcomes obtained by students in the experimental class were higher when compared to the control class, which did not use ARSINAPS media in learning. This statement is supported by theory and previous studies stating that AR influences academic achievement in several content areas, such as Biology (Jamali, 2017). AR has proven to be very useful in helping students with a visual learning style because it helps them visualize abstract concepts or phenomena that are difficult to observe (Wu et al., 2013). Visual illustrations can pave the way for learning apart from text-based knowledge (Erbas & Demirer, 2019).

Augmented reality has now been widely developed in natural sciences because AR provides the advantage of providing convenience in learning material with abstract concepts (Bacca et al., 2018; Garzón et al., 2019; Ibáñez et al., 2020). So that the development of AR-based learning media on biological material, such as that which has been developed in the form of the ARSINAPS application, is also believed to be able to provide later in learning the concept material related to the structure of organ-composing tissue and its relation to bioprocesses in the respiratory system because this material is also considered to have an abstract concept. Previous studies show that augmented reality has improved learning: learning gains, motivation, abstract concepts, autonomy, sensory engagement, memory retention, collaboration, creativity, and accessibility (Garzón et al., 2019). Of the nine things above, learning gain is the variable that most often experiences an increase with the use of AR as a learning medium. In his research results, Garzon states that when using AR, students improve their academic performance in class. Apart from that, AR can also increase memory retention; this technology helps retain knowledge and gives students the possibility to have long-term memory compared to other pedagogical methods (Chiang et al., 2014; Rodríguez-Abad et al., 2021; Zhang et al., 2020). When students have memory resilience for the concept of a material, it will be easier for them to apply the knowledge they have to solve new problems they get in the form of evaluations or activities in learning.

In Garzon's research, it was stated that the second variable most often influenced using AR is motivation. AR is trusted and proven in 46 articles of previous research results to increase student motivation. However, in this study, the opposite results were obtained. Namely, the use of ARSINAPS did not significantly affect students' learning motivation. Based on the results of a systematic review study, it was found that 15% of the results of previous research on AR stated that AR as a learning medium had several weaknesses, namely complexity, technical difficulties, multitasking, and resistance from teachers (Garzón et al., 2019).

The use of AR as a learning medium is sometimes felt to be too complex because it requires students to be able to do many things in learning activities; this can cause students to experience difficulties and stress, especially for those who need to be more skilled in using technology. The teacher's ability to use AR technology in the classroom is also crucial and influential. Teachers who need to be more skilled in using AR technology in the classroom limit the learning environment and make learning seem complicated so that students lose motivation. The things mentioned above are believed to be the causal factors that do not affect the use of ARSINAPS on students' learning motivation in class. Apart from that, using AR applications can increase learning motivation if integrated into the learning environment. In this research, the use of ARSINAP media in learning is only intended for research, so it is not fully integrated with all learning activities. Therefore, the use of the ARSINAPS application in learning is still not optimal, and this is one factor that makes its use not affect student learning motivation.

The next thing that is also suspected to be a factor that causes no effect of using ARSINAPS on learning motivation is the weakness of AR media which requires skills in using technology, so sometimes it requires much attention; this can be a disturbing factor that confuses students. The use of AR applications requires sufficient maturity in the use of technology and instructional directions from teachers related to meeting targeted knowledge needs. If these things are fulfilled, students become relaxed, and learning is pleasant. This situation does not significantly influence learning motivation, or the lousy impact can also reduce student learning motivation in class. Khan (2018) in his research also

stated that the use of AR, which is not accompanied by careful preparation regarding skills in using technology by both students and teachers, will have a cognitive overload effect which can lead to a negative attitude from students toward the learning process (Khan et al., 2019). Poor preparation while using AR as learning media can also be one of the factors causing ARSINAPS not to influence student learning motivation. Conduct further research to test the effectiveness of using media on other variables.

CONCLUSION

Based on the data calculations, the ARSINAPS learning media effectively improves student and undergraduate learning outcomes at the high-school and undergraduate levels. Meanwhile, this learning media still needs to be more effective in impacting changes in students' learning motivation for the high school level. Further research is needed to test the effectiveness of using ARSINAPS media in increasing learning motivation at the undergraduate level. The application being developed is still limited to just one biological material, and the use of markers is sometimes an obstacle in using the media; the use of large application memory is also one of the shortcomings of the developed media. So, further development must be needed to improve the media to become more effective in its use.

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