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The effect of using *ar sinaps* learning supplements on high school students' concept understanding of respiratory system topics

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ABSTRACT

There are many levels of objects studied in biology, and parts of the anatomy and physiology of the body still need to be appropriately understood. This problem needs to be clarified to enhance students' understanding of concepts in studying biology, especially in the respiratory system topic. This study aims to determine the effect of Augmented Reality-based learning supplements (AR SINAPS) on high school students' conceptual understanding of the respiratory system. This research was conducted in January-April 2023 at SMAN 38 Jakarta, Indonesia class XI MIPA. This study used a quantitative approach with quasi-experimental methods and pretest-posttest group experimental research designs. The sample was randomly selected using the simple random sampling technique of 62 students: 31 in the experimental class (using AR SINAPS) and 31 in the control class (using E-Module). Data were obtained using a conceptual understanding test instrument of 30 multiple-choice questions. Furthermore, the collected data were analyzed using descriptive analysis, and the enhancement in understanding the concept of the respiratory system was measured by the normality gain test (N-Gain). The N-Gain value for the experimental class was higher than the control class; the experimental class was 0.69, and the control class was 0.55. The results of the N-Gain percentage of both classes were in the medium category with different categories of effectiveness; the experimental class was quite effective, and the control class was less effective. Based on the study's results, the AR SINAPS learning supplement significantly affects high school students' conceptual understanding of the respiratory system.

INTRODUCTION

The application of technology in learning media is essential to support the effectiveness of delivering learning topics, especially in Biology subjects. The level and scope of the objects studied in the biological sciences are pretty numerous, abstract, and difficult to observe directly, especially the anatomical and physiological parts of the body. This can be a barrier that affects students' understanding of concepts in the study of biology, one of which relates to the topics of the respiratory system that requires an understanding of anatomy, physiology, and bioprocesses within it (Puspitasari et al., 2020).

The learning tree discussed in the respiratory system's topics is about the anatomical structure of respiratory organs, the physiological processes that occur in each organ, and diseases relating to the breathing system (Ritonga et al., 2018). A sufficiently compact topics that must be understood within a limited time requires the teacher to provide a good and correct understanding of essential concepts. Dewi & Widodo (2017) explains that students already have basic concepts that can originate from the surrounding environment and understanding of the previous level of education. However, inappropriate learning methods and strategies often lead to misconceptions about the topics of the respiratory system. This statement is also supported by the opinion of Widita et al., (2018) which states that in biology learning requires appropriate approaches and methods, particularly in delivering the concept of the respiratory system to be more effective and not just remembering.

According to a survey conducted by Sartono et al., (2018) in some high schools located in Jakarta, students need more understanding of concepts in biology learning due to their tendency to memorize rather than understand concepts well. Based on research conducted by Dewi & Widodo (2017), students' understanding of the respiratory system concept is still low, and misconceptions occur in almost every question. One of the topics that also suffered misconceptions is the concept of the structure of the human respiratory apparatus. Misconceptions about the learning topics can be caused by various factors, including a complex and impressive biological textbook filled with monotonous explanatory narratives that are quite difficult to interpret properly (Ritonga et al., 2018).

In school learning, a supplementary book or enrichment book is used as an accompaniment to complement the main teaching material. The existence of supplementation or enrichment also aims to suppress factors that can weaken students' mastery of topics concepts. In meeting the national curriculum, the learning supplement is characterized as a complement and accompaniment of the main reference of teachers and students in obtaining information about the topics studied. The information on the device used as a learning supplement enriches knowledge and strengthens the understanding of student concepts (Puspitasari et al., 2020).

Nevertheless, printed books remain the primary source as a grip on teachers and students in learning topics both in the classroom and at home (Väljataga & Fiedler, 2014). Tania et al., (2015) argued that there is a need for supporting media to complement print books and provide a more interactive learning experience in the learning process. On the other hand, the density of the learning topics causes information not to be fully accepted by students in the classroom. Media presence can help students learn independently at home. With technological advances in learning media, Augmented Reality (AR) available on mobile devices can be one of the media solutions and alternatives that teachers can use to help students learn independently (Adami & Budihartanti, 2016).

Augmented Reality (AR) is a technology that can visualize an object in the real world through mobile devices such as smartphones, laptops, and tablets. Several studies show that this instructional technology can improve learners' participation, competence, and learning motivation. In addition, learning through private-owned electronic devices that can be accessed whenever and wherever (mobile learning) is considered more flexible and effective (Mang & Wardley, 2013). Research conducted by Muali et al., (2020) showed a significant difference between the pretest and posttest scores of conceptual understanding in the experimental and control classes. Experimental class scores using Augmented Reality (AR) mobile-based devices were higher than control classes using traditional learning techniques. That statement shows an increased understanding of concepts after using Augmented Reality in the learning process.

Learning involving AR supports understanding concepts due to features allowing students to spin or move 3D objects and view them from various perspectives (Nurhasanah et al., 2019). The ease of mobile access Augmented Reality on mobile devices is one of the open learning resources that learners and the general public can use anytime and anywhere. Thus, AR-based mobile devices can

improve students' learning motivation and understanding of topics concepts (Hiranyachattada & Kusirirat, 2020). According to Taçgin et al., (2016), the learning process in the human brain requires quantification involving the sensory system actively. Augmented Reality (AR) has the potential to be able to translate and offer a variety of information, so it is suitable for use as an experimental learning method involving the participant's sensory system. One of the Augmented Reality (AR) based applications that support the biological learning process is *AR Sistem Pernapasan* (AR SINAPS). The development of AR technology as a supplement to learning encourages students to experience a collaborative learning environment by involving the interaction of sensory systems.

AR SINAPS is an Android app based on Augmented Reality (AR) technology that focuses on the structure and function from the tissue level to the organs of the respiratory system. This application aims to provide more profound visualizations from the organ to the cellular level in three-dimensional form, especially in the respiratory system topic. According Nugroho et al., (2021), supplementary topics based on Augmented Reality (AR) technology can create exciting learning for students and make it easier for them to construct information into complete knowledge. With the help of AR SINAPS, students are expected to understand the anatomical structure of the respiratory system topic so that it can be easier to understand the interrelationship of bioprocesses within it. Additionally, the student's need for teacher support as a learning facilitator and additional AR media as a supporter can strengthen the primary topic learned from physical textbooks.

Based on the above description, this research was conducted related to the influence of AR SINAPS learning supplements on the understanding of high school students' respiratory system concepts. The use of Augmented Reality as a learning supplement, it is expected to improve the understanding related to the concept of the respiratory system and shape students' autonomy in learning anywhere and anytime.

METHODS

Research Design

The study uses a quantitative approach with quasi-experimental research methods. The research design used is a pretest and posttest group experiment shown in Table 1.

Table 1
Pretest and Posttest Group Experiment Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	C	O_4

Notes:
X: Treatment of supplement learning with the Augmented Reality App (AR SINAPS)
C: Treatment of supplement learning with E-Module
O_1: Pre-test in the experimental class
O2: Post-test in the experimental class
O3: Pre-test in the control class
O4: Post-test in the control class

Sample and Population

This study was conducted in January-April 2023 at SMAN 38 Jakarta class XI of 2022/2023. The population in this study is the entire class XI student of MIPA SMAN 38 Jakarta, which is determined with purposive sampling techniques. Sampling is done using the simple random sampling technique. The total sample used was 62 students, with each class as many as 31 student samples.

Instrument

Test instruments are structured based on indicators of understanding concepts (interpreting, exemplifying, classifying, summarizing, concluding, comparing, and explaining) (Anderson et al., 2001). The test instruments used have been validated with the Pearson Bivariate Correlation Test and the reliability test with the KR-20 test. (Kuder-Richardson 20). The test consists of 50 double-choice questions with five answer options. The validity test results showed that 34 questions were valid with significant and highly significant categories. The reliability test results showed that the instrument had a reliability value of 0.87 with a highly reliable category.

Procedure

The research begins with identifying schools, samples, and learning devices of the human respiratory system, the AR SINAPS application learning supplement in the experimental class, and the E-Module as a learning addition in the control class. The instrument is a written test structured as multiple choice of 30 questions. Research data collection is carried out by providing pretests and posttests through Google Forms at the beginning and end of experimental and control learning classes.

Data Analysis Techniques

After obtaining scores from the instrument's pretest and posttest, data is processed with data analysis and hypothesis testing. The hypothesis testing using an independent t-test at a significance level of $\propto = 0.05$. The prerequisite test for data analysis is the normality test with the Kolmogorov-Smirnov test at the significance level $\propto = 0,05$ and the homogeneity testing with the F test at $\propto = 0,05$.

RESULTS AND DISCUSSION

Based on the research that has been carried out, the data obtained is the result of a test of understanding the concepts of the topic of the respiratory system in the experimental and control classes.

Table 2
Respiratory System Concept Understanding Test Results

	Experiment Class		Control Class	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Number of Samples	31.00	31.00	31.00	31.00
Minimum	30.00	67.00	37.00	67.00
Maximum	80.00	100.00	73.00	93.00
Range	50.00	33.00	36.00	26.00
Average	53.45	84.84	55.13	79.94

Table 2 shows that the results of the posttest of the experimental class using the learning supplement with the application AR SINAPS obtained an average score of 84.84. In contrast, the control class with the study supplement of the E-module receives an average rating of 79.94. Based on the concept understanding category, according to Kartika (2018), the experimental class using the AR SINAPS learning supplement obtained the number of students with the most posttest scores found in the very good category, while in the control class that used the E-Modul learning supplements the posttest score was the most in the good category. The average values of the experimental and control classes on each indicator can be seen in Table 3.

Table 3
The Average Value of Each Indicator on The Respiratory System

No.	Question Indicator	Experiment Class		Control Class	
		$\bar{X} \pm SD$ **Pretest**	$\bar{X} \pm SD$ **Posttest**	$\bar{X} \pm SD$ **Pretest**	$\bar{X} \pm SD$ **Posttest**
1	Explain the relationship between the location, organ structure, and function of the organ-composing tissues in the respiratory system.	62.26 ± 2.91	89.68 ± 1.87	63.23 ± 1.71	86.45 ± 1.69
2	Explain the relationship between the structure of the organ-composing tissue in the human respiratory system and the bioprocesses that occur in it.	50.97 ± 2,78	81.61 ± 2,31	49.03 ± 3,36	75.81 ± 2.07
3	Analyzing and linking the effect of air pollution to abnormalities in the structure and function of the respiratory system organs and forms of disease prevention.	47.10 ± 3.10	82.90 ± 2.41	53.23 ± 1.90	78.06 ± 1.75

Table 4
The Average Value and Standard Deviation of Each Indicator of Understanding the Concept of The Respiratory System

Indicators of Concept Understanding		Experiment Class		Control Class	
		$\bar{X}$ ± SD Pre-test	$\bar{X}$ ± SD Post-test	$\bar{X}$ ± SD Pre-test	$\bar{X}$ ± SD Post-test
C2.1	Interpreting	16.75 ± 5.44	26.75 ± 3.10	16.25 ± 4.27	23.75 ± 2.75
C2.2	Exemplifying	16.25 ± 4.86	27.50 ± 1.73	20.00 ± 1.83	25.50 ± 2.38
C2.3	Classifying	18.20 ± 4.09	28.60 ± 1.14	16.80 ± 2.49	25.00 ± 3.39
C2.4	Summarizing	15.50 ± 3.32	25.00 ± 3.16	13.50 ± 2.52	24.00 ± 2.16
C2.5	Inferring	17.40 ± 0.89	26.20 ± 0.84	17.80 ± 2.59	25.60 ± 1.52
C2.6	Comparing	15.50 ± 2.38	25.25 ± 2.63	17.25 ± 2.06	24.50 ± 2.08
C2.7	Explaining	15.75 ± 3.77	24.00 ± 1.41	18.00 ± 2.58	25.25 ± 2.36

Based on the average value of each indicator in Table 3 and Table 4, the lowest pretest value of the experimental class is on indicator 3, while the highest posttest average is on indicator 1. Further, in the control class, the lowest pre-test average value is in indicator 2, while the highest posttest average is in indicator 1. The experimental class that used the AR SINAPS learning supplement obtained the highest average score on the cognitive dimension C2.3 (classifying) and the lowest at C2.7 (explaining). In the control class that used the E-Module learning supplement, the highest average score was in the cognitive dimension C2.5 (inferring) and the lowest was in C2.1 (interpreting). Furthermore, a significant improvement in student understanding of the concepts of class experimentation and control can be seen through the N-Gain Score in Table 5.

Table 5
N-Gain score in Experimental Class and Control Class

Class	$\bar{X}$ ± SD	Gain Score	N-Gain Score
Pretest Experiment Class	53.45 ± 12.30	31.39	0.69
Posttest Experiment class	84.84 ± 8.77		
Pretest Control Class	55.13 ± 10.50	24.81	0.55
Posttest Control Class	79.94 ± 7.01		

In Table 5, the N-Gain score of the experimental class was achieved at 0.69, while the control class's N-gain score was obtained at 0.5. The N-Gain percentage values of the experimental class are more significant than the control class, and both, when categorized by Hake (2002), are in the medium category. Based on the N-Gain percentage effectiveness category, according to Mizrachi et al. (2020), the experimental class's N-Gain average belongs to the effective interpretation category, while the control class includes less effective (Tabel 6). This difference in N-Gain values suggests that the experimental class that uses the AR SINAPS learning supplement is more effective than the control class that utilizes the E-Modul Learning Supplement.

Table 6
Categories of the Percentage of N-Gain Values in the Experimental Class and Control Class

Class	N-Gain Score	N-Gain Score (%)	Category	Interpretation
Experiment Class	0.69	69.19	Average	Effective enough
Control Class	0.55	54.95	Average	Less effective

Prerequisite Test and Data Analysis

The significance values of the pretest and posttest experimental classes (AR SINAPS supplement) are more than 0.05, i.e. the pretest is 0.198 > 0.05, and the posttest is 0.092 > 0.05. Furthermore, the data of the pre-test and post-test results of the control class (E-Module supplement) also obtained a significance value of more than 0,05, the pretest 0.068 > 0.05, and the post-test 0.200 > 0.05. Next, for the homogeneity test results, the significance value of the pre-test of the experimental and control class was 0.422 (0.422 > 0.05). Subsequently, the posttest values of the experimental and control classes were also greater than the level of significance of 0.219 > 0.05. Based on the normality and homogeneity test results, it can be concluded that the study's data is normal and homogenous.

Table 7
Results of the Independent T-Test for Understanding the Concept of the Respiratory System

Class	df	Sig. (2-tailed)
Gain Score Experiment and Control Class	60	0.000

Table 7 shows that the t-independent Gain Score test results in the experiment and control classes were 0.05 (0,00 < 0,05). Based on the test results of the hypothesis, it was obtained that the use of AR SINAPS learning supplements influenced the understanding of the concept of the respiratory system of high school students. This proves that AR SINAPS provides a positive and significant influence in improving the understanding of high school students' concepts on the topic of the respiratory system. The average posttest and N-Gain of the experimental class are higher than the control class (Table 7). It is consistent with the results of research conducted by Muali et al., (2020) that there are significant differences in improved conceptual understanding between experimental classes that use Augmented Reality-based applications and control classes that do not use AR applications in their learning.

This significantly improved understanding of concepts is due to the learning experience of different experimental and control classes. Such learning experience differences can be reviewed from student accessibility in exploring AR SINAPS and E-Module learning supplements. In the implementation of learning carried out in the experimental class, students explore using the AR SINAPS learning supplement, while the control class used the E-Module study supplement when working on the group-solved student worksheet (LKPD). This worksheet (LKPD) is assigned to students during two learning meetings with a topic load that directs them to explore and discuss by applying AR SINAPS and E-Module as accompanying teaching topics in solving the LKPD. The use of the AR application SINAPS is a new thing for students of the experimental class XI MIPA 3, while using the learning supplement E-Module in the control class X MIPA 4 is already and is still done now.

The up-to-date use of AR SINAPS learning supplements in implementing classroom learning affects students' interest and activity. On the implementation of learning, the interest and activity of students is higher in the experimental classes using AR SINAPS, especially when they directly explore the 3D characteristic components of organ structures and tissue of the respiratory system. Students in the experimental class appear to be more active and enthusiastic to complete answers to questions in the LKPD than in the control class. This is in line with the results of research from Aldalalah et al., (2019) that stated that the Augmented Reality application could increase the motivation and activity of students in the learning process so that it can make a significant difference in learning outcomes.

Based on the research results by Rini et al., (2022), the AR SINAPS application has interactive features that are easy to use. It can build a pleasant learning atmosphere to help strengthen student understanding regarding object visualization. Following the study's results, the highest post-test average values on the first indicator of this study were obtained by a class of experiments that discussed the location, structure of organs and tissue function in the organs of the respiratory system. This suggests that students in the experimental class better understand the concepts related to the placement, structure, and function of the respiratory system organ compared to the control class, whom they study without the help of animating objects visualization. The results of this research are also supported by Puspitasari et al., (2020) research where animated learning media based on Augmented Reality-based learning supplement applications help cognitive learning activities by facilitating the delivery of the topics so students can be more easily understood.

Not only did the average posttest values of the experimental class on indicator 1 get higher values than the control class, but also on indicators 2 and 3. In the AR application SINAPS, experimental class students can use 3D display features to visualize objects and access modules, video learning, and evaluations in the application at anytime, anywhere, both online and offline. In the experimental class, the lowest post-test average value is in the second indicator that explains the correlation between the organ's structure and its respiration bioprocesses. The acquisition of low average values compared to other indicators can be because the information and video learning about the bioprocess of the respiratory system in the AR SINAPS application still needs to be more facilitated and fully informative in providing an understanding to the student.

The average posttest values of the control class on the first, second, and third indicators using the E-Module as supporting teaching topics also increased when compared to the pre-test average values. However, an improved understanding based on the posttest and N-Gain averages in the control

class was interpreted as less effective in improving student understanding of the concepts of the respiratory system material. On implementing learning in the control class using the E-Module, the average posttest value of indicator one also appears to be higher than indicators two and three. In the implementation of learning in the class that uses the E-Module, students do not seem to pay much attention to the overall content that exists on the E-Module. They prefer to search for additional information from the internet rather than the information of images or writing that exists on the E - Module. The content on the E-Module of the respiratory system presented for the control class is limited to images, writing, and video learning links. This allows students also to feel saturation because the learning interaction patterns obtained have often been done.

Research that refers to an increased understanding of concepts requires the involvement of the student's senses and a collaborative learning ecosystem. Based on observations and questions to teachers and students in the school, they said that applying additional teaching topics such as E-Module is not new. Students have been accustomed to using E-Module since learning biology in pandemic times. According to Ionescu et al., (2020) , the application of various learning platforms and media formed by electronic modules accessible online has begun to rise from pandemic times to learning today. This is also supported by Thirraja et al., (2023), where the electronic module (E-Module) is one of the commonly used learning media. However, in its implementation, there are still limitations in some subjects.

According to Peserta et al., (2016), the use of animation-based learning media increases the enthusiasm and activity of students, which helps them to understand material concepts more quickly than in classrooms that only use frequently used learning media. In line with this opinion, Iqbal et al., (2019) argued that the current approach in the learning process facilitates kinesthetic learning "learning by doing" so that the mastery of material concepts is faster, and one of them is through the help of augmented reality technology. Based on some previous opinions, it is understandable that one of the learning media that can potentially improve student understanding of concepts is Augmented Reality-based media.

Implementing learning in the classroom allows students to obtain additional information beyond AR SINAPS and E-Module learning supplements so that students can still search, find, and combine information obtained from the internet or the main printed books. This aligns with the principle of using the learning model of discovery learning that applies a student-centered approach. The involvement of supplemental learning in the application of AR SINAPS to learning that applies a student-centered approach has proved significant and effective in improving the understanding of student concepts in the material of the respiratory system. The approach used in this learning model helps students construct the knowledge and experience acquired. The learning process with the discovery learning model trains students to learn independently in finding and formulating theories with or without the teacher (Sari & Cahyo, 2020). This is also supported by the results of research conducted by Khansa (2022) where there is an influence of the use of AR SINAPS learning media on the learning results of high school biology that also uses the learning model of discovery learning. The research provides confirmation that AR SINAPS is effective and ideally used as additional teaching material in the learning process.

The student's curiosity in the experimental class seemed much higher due to his sense of targeting the basic features of Augmented Reality on the AR SINAPS application. This is in line with Sugiarto (2022) the opinion that with the use of media or Augmented Reality-based apps integrated with smartphones, students feel more motivated so that it is easy to accept and understand the material, and this will affect the value of knowledge, skills, as well as attitudes. It also proves that adding add-ons or learning supplements based on Augmented Reality makes learning more interactive and exciting so that students are interested in better understanding the topics. This is also in line with the results of research Rafik et al., (2022), where the use of Augmented Reality as a resource or medium of learning can provide more support to students in understanding the material so that it can improve the quality of learning. Shatte et al., (2014) also stated that Augmented Reality media on smartphones has the potential to increase student attraction, thereby building motivation and curiosity and strengthening memory.

AR SINAPS application is one of the renewals of learning supplements in biological learning, especially on the material of the human respiratory system. The ease in operational mobility, information load and evaluation, and the 3D visualization experience add value for AR SINAPS as a

learning supplement compared to additional media teaching (Rini et al., 2022). In addition to its advantages, AR SINAPS has some other disadvantages, as well as the E-Module, which is used to supplement the study of the respiratory system in this study. However, the results of the N-Gain values shown in Table 7 confirm that there was a significant improvement in conceptual understanding in the experimental class with the AR SINAPS learning supplement. Then when reviewed based on the effectiveness of N-Gain values on experimental and control classes, it was concluded from Table 6 that experimental classes using AR SINAPS learning supplements were quite effective in improving the understanding of respiratory system concepts.

Based on the implementation of the overall learning, both the experimental and control classes went smoothly. Nevertheless, some things still need more attention and evaluation to optimize the learning process. In the experimental class, the time spent introducing the application and its operation slightly exceeds the specified time limit because students need more than one instruction. This contributes to reducing time allocation in the workings of the student worksheet. Therefore, teachers are expected to be able to guide to download and explain the use of AR SINAPS applications at previous learning meetings or outside of biology lessons.

Furthermore, students in the control class seem more easily instructed to complete the worksheet (LKPD) with E-Modules. However, the control class conditions are less favorable due to a few students needing more attention and guidance. In addition, the schedule of learning biology in the control class is mixed with the break hours of lessons. This causes the teacher to need extra time to condition the class to return conducive and can continue to work on the student worksheet.

CONCLUSION

Based on the results of data analysis and discussion, it was concluded that AR SINAPS learning supplements had an influence on the understanding of high school students' respiratory system concepts. AR SINAPS learning supplement can significantly improve conceptual understanding and is quite effective due to students' high level of curiosity and activeness.

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