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The Influence of Visual Thinking Strategy In Augmented Reality (ViTSAR) to Improve Students' Visual Literacy Skills on Magnetic Field Material

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ABSTRACT. The purpose of this study was to examine the effect of ViTSAR in improving students' Visual Literacy Skills on magnetic field material. The research location was at SMAN 1 Baros in the 2024/2025 academic year. The research method used was a quantitative research method. This type of research is a quasi-experiment with a pretest-posttest nonequivalent control group design. The population of the study was all grade XII MIPA students at SMAN 1 Baros. The sample of this study was 32 grade XII MIPA 1 students as the experimental class and 32 grade XII MIPA 2 students as the control class. The instruments used in this study were Visual Literacy Skills test questions and student response questionnaires. The results of the t-test obtained a significance of 0.001, meaning that the t value was significant ($p = 0.001 < 0.005$), so there was an influence of the Visual Thinking Strategy in Augmented Reality (ViTSAR) learning media to improve Visual Literacy Skills on Magnetic Field material. The results of students' responses to learning using ViTSAR media were very good, obtaining results of 80% so that this method can improve students' Visual Literacy Skills, especially in learning physics on magnetic field material.

1. Introduction

Physics is one of the subjects taught in high schools and equivalent. Students' conceptual understanding plays an important role in physics learning (Rose Amanda Puri & Riki Perdana, 2023). One of the physics sub-chapters that is prone to misconceptions is the magnetic field material (Setyaningsih, 2018). Misconceptions in magnetic field material can have a significant impact on the understanding of other related physics concepts. In previous research, Setyaningsih (2018) identified that students experience misconceptions about the concept of force on charged particles moving in a magnetic field, with a percentage reaching 81.63%. This misconception can hinder students' understanding of the concept of Lorentz force, which is the basis for understanding electromagnetism phenomena further. In addition, misconceptions were also found in the concept of magnetic fields at the center of the solenoid by 68.37%, which can affect students' understanding of electromagnetic induction and its practical applications in technologies such as transformers and electric motors. Therefore, it is important for educators to identify and address these misconceptions so that students can build a comprehensive and accurate understanding of physics.

Based on an interview with one of the physics teachers at SMAN 1 Baros, it was revealed that students had difficulty understanding the concept of magnetic fields, especially in determining the direction of the magnetic field. Learning media such as PowerPoint, PhET simulations, and Quizizz are less effective in visualizing the material, while teachers face time constraints to deliver the material efficiently. Furthermore, interviews with representatives of grade 12 MIPA students showed that two out of three students still had difficulty understanding the magnetism material and needed visual media to support their understanding of the magnetic field material.

This is reinforced by Afriyanto's research (2015), which revealed that students still have difficulty understanding the physics concept related to magnetic fields because of their invisible nature. In addition, research by Pateda et al., (2015) stated that students' understanding of the concept of magnetic fields, including the direction of magnetic force, magnetic fields, and electric currents using the right-hand rule, is still low. Scaife & Heckler (2010) also found that many students experience misconceptions in understanding the representation of magnetic field lines, especially regarding their direction and application. To overcome this problem, visual literacy skills or Visual Literacy Skills are needed to help visualize the concept of magnetic fields.

Visual literacy involves the ability to interpret, analyze, synthesize, and evaluate visual information (Sukserm & Wasanasomsithi, 2023). A person with visual literacy skills can understand and apply visual language in communication and interaction (Sidhartani, 2016). Visual literacy skills are very important in physics learning because they help students understand complex concepts through visual representations such as images, graphs, and models. Research by Montalbano (2014) shows that visualization of phenomena that cannot be directly sensed can improve students' understanding of abstract physics concepts. Therefore, it is important to facilitate Visual Literacy Skills in students in magnetic field material.

To facilitate visual literacy skills, appropriate strategies are needed in learning (Lohr, 2008). Visual Thinking Strategy (VTS) is one of the learning strategies that can encourage active thinking and analytical processes to understand, interpret, and produce visual messages (Sutama, 2020). The solution to support Visual Thinking Strategy is to develop effective, appropriate learning media and use relevant technology. One technology that can be utilized is augmented reality (Nainggolan et al., 2018). Augmented reality in principle is creating three-dimensional images that appear real (Rizqillah & Kholiq, 2023). Augmented reality can be used to help visualize abstract concepts for understanding and the structure of an object model (Balandin et al., 2010).

In previous research, namely Nave's research (2024) using digital LKPD teaching materials obtained a score of 88% with a very good category, Elsayed & Al-Najrani's research (2021) using augmented reality technology concluded that the experimental group surpassed the control group in visual thinking and academic motivation which means recommending the involvement of augmented reality technology, and research According to Syarbini et al., (2023) using this E-Module was considered very valid (suitable) for use with a percentage of 94.23%. This third study has its own advantages, but none has combined digital LKPD (structured), augmented reality (interactive), and e-modules (comprehensive) in one integrated learning platform.

In addition, previous studies also did not detail the effectiveness of learning media in the duration of classroom learning which is an obstacle to current physics learning. In physics learning, especially in the complex and misconception-prone concept of magnetic fields, teachers often face difficulties in delivering material efficiently without conveying the depth of students' understanding. Therefore, innovation is needed to overcome these limitations by providing learning media that are not only effective in improving visual literacy, but also efficient for teachers in delivering material systematically.

The most complete learning media to improve students' visual literacy skills is the Visual Thinking Strategy in Augmented Reality (ViTSAR) learning media. ViTSAR is a learning media that integrates Visual Thinking Strategy (VTS) with augmented reality technology, equipped with e-modules, Student Worksheets, and the ViTSAR application. With ViTSAR, teachers not only obtain learning media that clarify abstract concepts in physics, but also have practical solutions to manage time more efficiently, ensuring that each student gets optimal understanding without being constrained by limited learning duration. To prove this, ViTSAR needs to be tested on students. This study aims to examine the effect of ViTSAR in improving students' Visual Literacy Skills on magnetic field material.

2. Research Method

2.1 Research Design

This type of research is a quasi experiment with a pretest-posttest nonequivalent control group design. In this design there are 2 predetermined classes, namely the experimental class using ViTSAR media and the control class using conventional methods. The first class, namely the experimental group, was given treatment (X) and the second class, namely the group that was not given treatment (Y) (Sugiyono, 2014). This research design can be stated in **Table 1.** below:

Table 1. Research Design Pretest-Posttest Nonequivalent Control Group Design

Class	Pretest	Treatrment	Posttest
Experiment	O_1	X	O_2
Control	O_3	Y	O_4

Information :
O_1 = Pretest in the experimental class before being given treatment
O_2 = Pretest in the control class before being given treatment
O_3 = Posttest in the experimental class that was given treatment
O_4 = Posttest in the control class that was treated

2.2 Population and sample

The population of this study was all students of class XII MIPA at SMAN 1 Baros in the 2024/2025 academic year. Meanwhile, the sample to be used in this study consisted of two classes, namely class XII MIPA 1 as the experimental class and class XII MIPA 2 as the control class.

2.3 Research instrument

The research instrument is a tool for collecting research data. The research instruments used in the study were Visual Literacy Skills Test Questions and student response questionnaires. The Visual Literacy Skills Test Questions instrument in this study consisted of 8 multiple-choice questions with Visual Literacy Skills indicators, namely visual thinking, visual association, meaning construction and meaning reconstruction. The Visual Literacy Skills test question grid can be seen in **Table 2.**

Educational Unit : High School
Material : Magnetic Field

Number of Questions : 8
Question Format : Multiple Choice with explanation

Table 2. Visual Literacy Skills Test Question Grid

Variables	Indicator	Question Indicator Description	Question Number
Visual Literacy	Visual thinking	Converting the form of information into the direction of magnetic induction with the help of the right hand rule.	1
		Changing the form of information into a picture of the direction of magnetic lines of force with the help of the right hand rule.	2
	Visual Association	Relate the direction of the magnetic field determined using the right hand rule with the coordinate axis system (X, Y, Z) to determine the correct direction of magnetic induction at point O.	3
		Connect the two wires to determine the magnitude and direction of the current.	4
	Construction of Meaning	Determining the equation of the long straight wire image presented.	5
		Determine the equation of the image of a wire carrying current I formed as a semicircle.	6
	Reconstruction of Meaning	Calculating the magnetic induction at the center of a solenoid.	7
		Calculate the magnetic induction at the center of the curve.	8

The student response questionnaire instrument that will be used to determine students' responses to the influence of ViTSAR learning media on magnetic field material. The use of this questionnaire instrument aims to provide conclusions obtained from objective and valid research. The questionnaire used in the study is a Likert scale model in the form of a rating scale, namely Strongly Disagree (STS), Disagree (TS), Sufficient (C), Agree (S) and Strongly Agree (SS).

3. Result and Discussion

The first research hypothesis in this study is the Influence of Visual Thinking Strategy in Augmented Reality (ViTSAR) Learning Media to improve students' Visual Literacy Skills on magnetic field material which is measured by comparing pretest and posttest scores. Both of these scores are obtained from the results of working on the same Visual Literacy Skills questions. After ensuring that the data is normally distributed and has homogeneous variance. Data analysis is continued with a t-test (independent sample test) using IBM SPSS software to determine significant differences between pretest and posttest scores in the experimental and control classes.

The average score of Visual Literacy Skills improvement in the experimental group was 6.44 and the control group was 3.75. If compared directly with the average value, it will be seen that the mastery of Visual Literacy Skills in the experimental group is higher than the control group.

Table 3. Group Statistic

Class		N	Mean	Std. Error Mean
Results	Gain Eksperiment	32	6,44	2,031
	Gain Control	32	3,75	1,626

The decision making of the t-test to accept or reject the t-test, namely H0 at a significance level of 5% is:

H1 is accepted and H0 is rejected, if sig(2-tailed) < 0.005

H1 is rejected and H0 is accepted, if sig(2-tailed) > 0.005

H0 is that there is no influence of the Visual Thinking Strategy in Augmented Reality (ViTSAR) learning media to improve Visual Literacy Skills on the Magnetic Field material.

H1 is that there is an influence of the Visual Thinking Strategy in Augmented Reality (ViTSAR) learning media to improve Visual Literacy Skills in the Medan Magne material.

Table 4. t-Test Results

Independent Samples Test						
			t-test for Equality of Means			
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
5,938	62	,001	,458	2.84424	1,803	3,634
5,938	59,347	,001	,458	2.83322	1,803	3,635

By using the independent sample t-test, the sig(2-tailed) value in the table is 0.001, which indicates that the sig(2-tailed) value is less than 0.05 (0.001 <0.05). Based on this test, it can be concluded that H_1 is accepted, which means that there is an influence of the Visual Thinking Strategy in Augmented Reality (ViTSAR) learning media to improve Visual Literacy Skills on the Magnetic Field material. It can be concluded that there is an influence of Visual Thinking Strategy In Augmented Reality (ViTSAR) to improve students' Visual Literacy Skills on the magnetic field material. The distribution of students' mastery of Visual Literacy Skills based on each indicator can be seen in **Figure 1.**

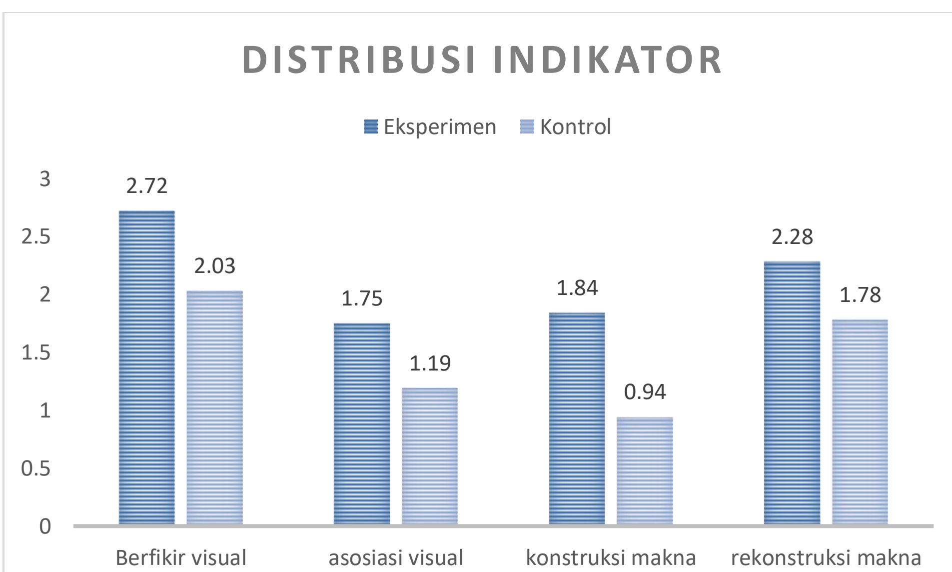
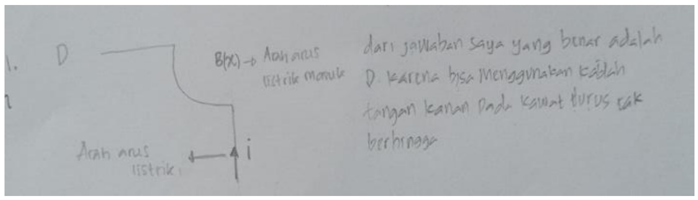
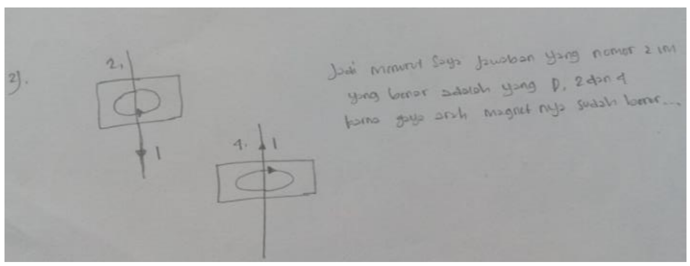


Figure 1. Distribution of Visual Literacy Skills Mastery based on each indicator

Indicator 1 (Visual Thinking) on average mastered by students in the experimental class is shown by an average score of 45% (average indicator 1 2.72 points out of 6 points) while in control class students it is around 34%, indicator 2 (Visual Association) is around 1.75% in experimental class students and 20% in control class students, indicator 3 (Meaning Construction) is around 1.84% in experimental class students and 16% in control class students and the last indicator is indicator 4 (Meaning Reconstruction) is around 38% in experimental class students and 30% in control class students. The discussion for each indicator will be discussed further in the following explanation.



(a)



(b)

Figure 2. (a) Example of experimental class students' answers to question number one with visual thinking indicators; (b) Example of control class students' answers to question number two with visual thinking indicators.

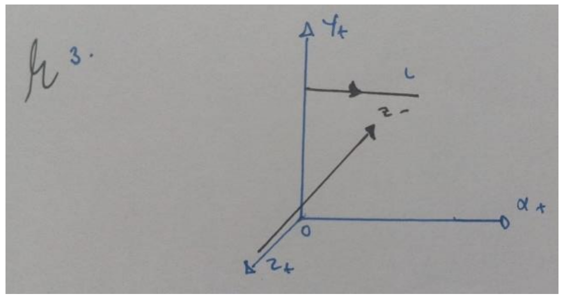
Figure 2. (a) shows the answer of one of the experimental class students who mastered the visual thinking indicator on question number one. This indicator is intended to change information from all forms into images, graphs or other forms through information filtering. Based on the image, the student is able to identify the information in the question and change it into the form of a right-hand rule image that shows the direction of magnetic induction correctly.

In **Figure 2.** (a). also shows the percentage of students who correctly answered question number one on the better visual thinking indicator, namely in the experimental class. In the experimental class, students were able to understand and answer the question because they were supported by ViTSAR learning media integrated with augmented reality technology which can facilitate students to be able to imagine or visualize the direction of the magnetic field. This is supported by Alfitriani et al., (2021), that Augmented Reality (AR) can help visualize an abstract concept so that it can improve understanding of the structure of an object. In this case, students can visualize the direction of the magnetic field on an infinite straight wire well.

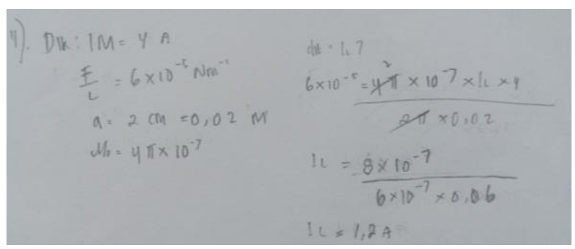
Figure 2. (b) shows the answers of control class students related to the visual thinking indicator in question number 2. As in the picture, many students did not answer this question and were wrong in changing the form of information into a picture of the direction of magnetic force lines around a wire carrying electric current. The students were fooled by the other answer choices and only focused on the similarity of the picture, not on the direction of the magnetic field. Added to this is the lack of in-depth understanding of the visualization of the infinite straight wire material, where the direction of the magnetic field should be clockwise and perpendicular to the direction of the electric current. In line with Setyaningsih's research, (2018) found that 45.45% of students had misconceptions about the concept of a magnetic field around a

straight wire carrying electric current. This shows that almost half of the students have a wrong understanding regarding the direction of the magnetic field produced by a wire carrying electric current.

The percentage of the experimental class that answered correctly was better than the control class. This is because in the experimental class there is a looking stage that can identify problems through the activity of seeing and collecting visual objects in a structured manner, this helps students in working on questions with visual thinking indicators.



(a)



(b)

Figure 3. (a) Example of experimental class students' answers to question number one with visual association indicators; (b) Example of control class students' answers to question number two with visual association indicators.

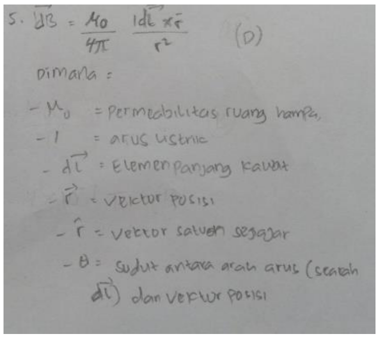
Figure 3. (a) shows the answer of one of the experimental class students who mastered the visual association indicator on question number three. This indicator is intended to connect images that display the unity of the theme presented in the form of questions. Based on the image, the student is able to connect the direction of the magnetic field determined using the right hand rule with the coordinate axis system (X, Y, Z) to determine the correct direction of magnetic induction at point O.

In **Figure 3.** (b) also shows the percentage of students who correctly answered the questions and reasons correctly which is better, namely in the experimental class. In the experimental class, students were able to understand and answer the questions because they were supported by the ViTSAR learning media which could connect the coordinate axis system (X, Y, Z) with the direction of magnetic induction O. In addition, the ViTSAR media also has a seeing stage, which is one of the stages of the virtual thinking strategy that helps students understand problems and opportunities with the activity of selecting and grouping. This is reinforced by another study which found that the use of virtual simulation media in physics learning can improve students' conceptual understanding. Virtual simulation allows students to visualize abstract physics phenomena, such as magnetic fields, making it easier for them to understand (Agustini et al., 2018).

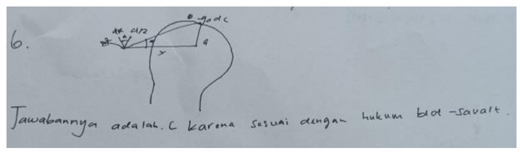
Figure 3. (b) shows the answers of control class students related to the visual association indicator on question number four. As in the picture, students can connect two wires L and M 2 cm apart from each other, determine the distance between the 2 wires, determine the current strength at M and the repulsive force per unit length and determine the appropriate formula. The student's weakness in question number four is in calculating the final result. This occurs due to the lack of basic calculation skills validated by the SMAN 1 Baros Teacher that the basic mathematics skills of grade 12 students at SMAN 1 Baros are still

lacking. This is in line with the research of Tulende et al., (2021) which revealed that mathematical knowledge is an important prerequisite as initial knowledge that students must have before studying physics. In this case, basic mathematical knowledge is important for working on questions on the magnetic field material.

In this visual association indicator, the percentage of the experimental class that answered correctly was better than the control class. This shows that learning using ViTSAR media can improve the visual association indicator.



(a)



(b)

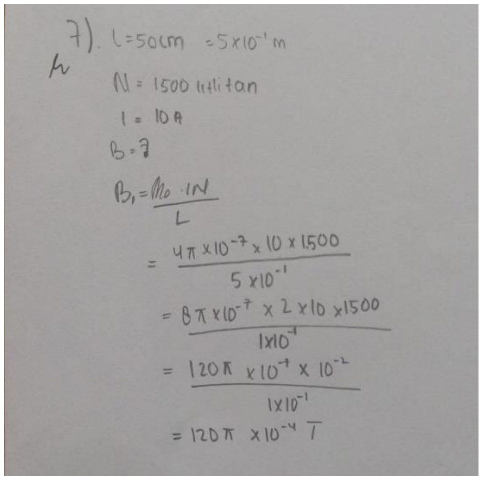
Figure 4. (a) Example of experimental class students' answers to question number five with meaning construction indicators; (b) Example of control class students' answers to question number six with meaning construction indicators.

Figure 4. (a) shows the answer of one of the experimental class students who mastered the meaning construction indicator in question number five. This indicator is intended to construct meaning from the visual message given. Based on the image, the student is able to construct information from the image of an infinite straight wire so that he can determine the equation of the image of a long straight wire presented.

Students have shown good ability to derive equations from infinite straight wire images. In the image, it shows that students are able to mention the units contained in the image, namely the permeability of a vacuum, the electric current flowing through the wire, the length element of the wire that carries the current, the position vector, the unit vector and the angle between the current direction (in the same direction dL $^{\rightarrow}$) and the position vector r $^{\rightarrow}$. This is because in the ViTSAR learning media there is an imagining stage, namely generalizing the steps to find solutions and pattern recognition activities, this helps students to find solutions to problems through images or visual messages that can be derived into appropriate equations. In addition, the ViTSAR LKPD also helps students determine each step by step in solving the formula derivation, this makes students better understand each step of the formula derivation. In line with the research of Rizti Yovan & Kholiq (2021), that augmented reality-based learning media is effective in training students' abstract thinking skills, facilitating understanding of magnetic fields through 3D visualization, and helping to derive equations.

Figure 4. (b) shows an example of a control class student's answer to question number six with the meaning construction indicator, this indicator is the ability to construct meaning from the visual message given. In the picture, students can re-draw a circular wire carrying electric current along with its variables. However, students have not been able to derive the equation from the image obtained. This shows a lack of student understanding of the visualization of a circular wire carrying electric current coupled with a lack of in-depth understanding of the material. One of the factors causing this is learning with conventional methods using textbooks that are less interactive and have not been able to visualize and direct students to derive formulas periodically. Coupled with the lack of students' mathematical abilities in deriving formulas. For example, research by Nurmaulida & Susanna (2018) found that mathematical abilities, such as linear equations, affect physics learning outcomes in temperature material.

The percentage of the experimental class that answered correctly did it better than the control class. This shows that ViTSAR media is better at improving the meaning construction indicators.



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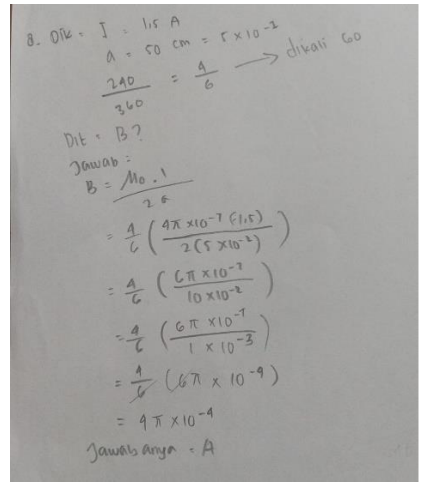

(b)

Figure 5. (a) Example of experimental class students' answers to question number seven with the meaning reconstruction indicator; (b) Example of control class students' answers to question number eight with the meaning reconstruction indicator.

Figure 5. (a) shows the answer of one of the experimental class students who mastered the meaning reconstruction indicator in question number seven. This indicator is intended to reconstruct the visual message in its original form. Based on the image, the student is able to reconstruct the information so that he can calculate the magnetic induction at the center of the solenoid.

Students have demonstrated a good understanding of the concept of solenoids through their ability to implement the problem-solving plan. Starting from the initial step of calculating the length of the solenoid, determining the current flowing and the number of turns, students also demonstrated good mastery of the concept by choosing a formula that is appropriate to the conditions of the problem. The last step, namely magnetic induction at the center of the solenoid, was also done correctly. This indicates that students have a good understanding in reconstructing information or visual messages into their original form.

Students in the experimental class were able to solve the problem because in ViTSAR there is also an imagining stage, namely deriving the appropriate equation in the problem, after which it is continued with the showing and telling stage, namely solving the problem by deriving the equation that has been obtained in the previous stage. This really helps students in answering the question of determining magnetic induction at the center of the solenoid because the stages worked on by students are more structured. A study conducted by Trisnawarni & Yunianta (2021) shows that students fulfill all stages of visual thinking according to Bulton, namely 'looking', 'seeing', 'imagining', and 'showing and telling'. The 'imagining' stage helps students in deriving the appropriate equation in the problem, while 'showing and telling' helps in solving problems by deriving the equation that has been obtained.

Figure 5. (b) shows the student's answer related to the reconstruction indicator in question number eight. As in the picture, the student is correct in reconstructing the information in the form of an image to determine the magnetic induction at the center of the circle, but is wrong in calculating the final result. In the picture, the student is wrong in determining the angle of the circle, it should be $\frac{120°}{360°}$ but the student answers $\frac{240°}{360°}$ degrees, this changes the final result obtained which should be $2 \times 10^{-7}T$ T to $4 \times 10^{-4}T$. Coupled with the low percentage in answering questions due to the lack of basic calculation skills validated by one of the SMAN 1 Baros teachers that the basic mathematics skills of grade 12 students at SMAN 1 Baros are still lacking. Research by Trisnawarni & Yunianta (2021) also shows a significant positive relationship between basic mathematics skills and physics learning outcomes. Students with low basic mathematics skills tend to have difficulty in physics calculations, which can lead to errors in determining the final results.

The percentage of the experimental class that answered correctly did it better than the control class. This shows that the ViTSAR media is better at improving the meaning reconstruction indicator. The results of the questionnaire are shown in **Figure 6**.

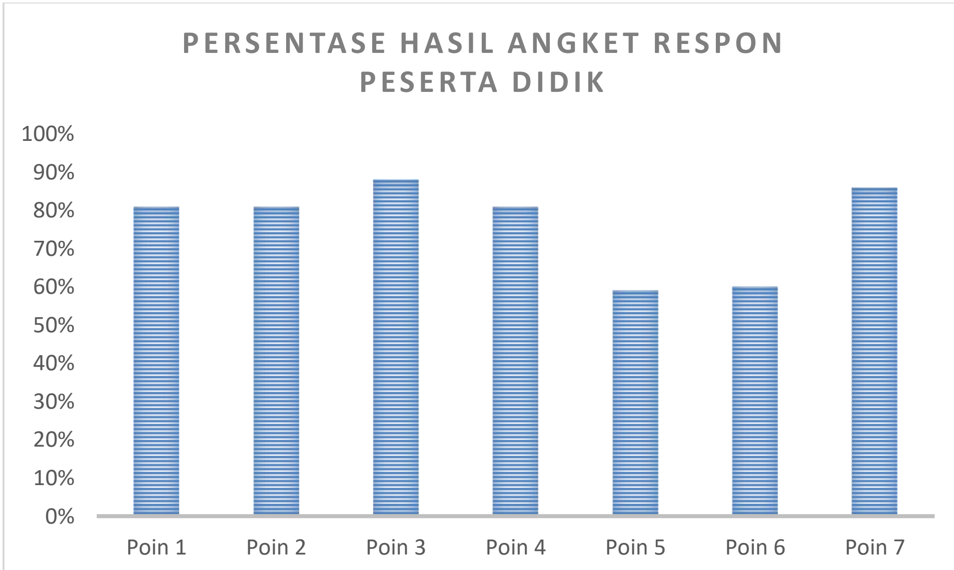

Figure 6. Percentage of Student Response Questionnaire Results

Based on the results of the student response questionnaire on the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media, it can be seen that 81% of students are very happy to follow physics learning using the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media. As many as 81% by using the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media, students' visual literacy skills are facilitated. As many as 88% of students agree that the implementation of the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media makes physics subjects more interesting and enjoyable. As many as 81% of the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media can motivate students to be more active in the ongoing learning. As many as 59% of students feel that the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media makes learning boring. As many as 60% of students find it difficult in the learning process with the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media and as many as 86% of LKPD help students understand the magnetic field material.

The results of the questionnaire that has been filled out by students show that the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media can improve students' Visual Literacy Skills in the magnetic field material.

4. Conclusion

ViTSAR learning media is effective in improving students' Visual Literacy Skills on magnetic field material. Experimental class students showed better understanding in visual thinking indicators, visual associations, meaning construction, and meaning reconstruction compared to the control class. This shows that augmented reality technology-based learning that integrates Visual Thinking Strategy (VTS) can be an innovative solution to overcome the challenges of physics learning, especially in understanding abstract concepts such as magnetic fields. In addition, the results of the questionnaire that has been filled out by students show that the Visual Thinking Strategy In Augmented Reality (ViTSAR) learning media can improve students' Visual Literacy Skills on magnetic field material. It is hoped that this media can be widely applied to improve the quality of physics learning in schools.

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