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Misconception and scientific attitude of teacher towards elementary school geometry assessed from information technology transformation

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Abstract

There is a misconception about elementary school geometry material that makes the teacher's scientific attitude in implementing learning in the classroom still not optimal and causes the application of IT transformation to be uneven. This research aims to describe the misconceptions about geometry among elementary school teachers, the scientific attitudes of elementary school teachers in the process of learning geometry, and how elementary school teachers overcome misconceptions and optimize scientific attitudes learned from the role of IT. The subjects of this study were 171 teachers from 18 districts and cities. The research was conducted in a descriptive qualitative form by giving questionnaires about elementary school geometry concepts and teachers' scientific attitudes toward learning, analyzing answers according to criteria, and exploring the relationship between misconceptions and scientific attitudes learned from IT transformation. The results of this study indicate that conceptual errors were found in the research subjects, which included generalization and specialization misconceptions; the teacher's scientific attitude influences the misconceptions experienced; and the role of IT can help calculate and visualize abstract things in learning. The application of IT in the learning process shows good results for overcoming teachers' misconceptions and scientific attitudes, and of course, it can be an option for teachers to be able to apply it with various IT-based learning media that attract students' learning interests.

INTRODUCTION

Geometry is one of the mathematics subjects taught at the elementary school level (Sari et al., 2021; Ulum, 2018). The introduction of geometry in elementary schools aims to allow students to analyze more about the world around them and have a foundation in the form of basic mathematical concepts needed for higher studies (Dzulfikar & Vitantri, 2017; Putri et al., 2023; Sari et al., 2021). Building geometric concepts in students must begin by recognizing shapes, investigating buildings, separating ordinary images, and learning about layout (Abualdenien & Borrmann, 2022; Larkin et al., 2019; Supriadi, 2019). Learning geometry in elementary schools is considered vital because it can help develop students' spatial abilities, which will become essential skills for understanding and exploring the physical world around them (Amir et al., 2018) and building and developing logical thinking skills (Pasani, 2019). Learning geometry itself requires appropriate teaching materials to be able to teach an understanding of concepts that is acceptable to students (Nury & Tri, 2019). The use of IT in learning geometry in elementary schools is also becoming increasingly important in the development of the 21st century because it will help students understand mathematical concepts (Amir et al., 2020).

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The survey of 115 elementary school teachers in Pontianak City revealed several things. First, 87% of learning geometry is done without the help of conventional or digital media because teacher-made teaching aids have become a habit for teachers and students. Second, only about 15% of teachers have ever used an app to explain geometry concepts because it is considered time-consuming to understand how to use it. Related to information technology (IT), it was revealed that 45% of teachers had not used IT to overcome obstacles in learning or misconceptions found in students due to limited equipment in schools and the need to redesign basic competencies to suit student characteristics.

This shows that the scientific attitude has not dominated teacher activities during the learning process. Scientific attitudes in learning influence students' actions to meet the requirements for changing competencies (Murningsih et al., 2016; Pamuji et al., 2019). Scientific procedures in changing competence will form scientific attitudes such as curiosity, caring, honesty, discipline, prudence, openness, cooperation, and wise and fair considerations (Ardiansyah & Arda, 2020). Teachers and students need to have a scientific attitude to achieve learning objectives as expected (Rahayu, 2021; Suryantari et al., 2019). If the teacher owns some or all of the scientific attitude, then the scientific attitude will gradually and consistently be owned by the students. Reviewing the teacher's scientific attitude is necessary to make students understand geometric concepts well (Murningsih et al., 2016). The teacher's scientific attitude will determine the teacher's perception of related concepts, and the teacher's perception will affect student understanding (Suryantari et al., 2019; Trianto, 2010). The lack of scientific attitudes found in teachers and students can lead to the misinterpretation of a geometric concept or what is known as a misconception (Gunada et al., 2015; Maesyarah et al., 2015).

The misconception referred to in this study is the understanding of the concept of learning geometry in elementary schools, which is not following the concepts put forward by scientists. This misconception can hinder their performance and learning. Educators must diagnose and address student misconceptions before teaching new concepts to ensure students have a solid foundation for understanding mathematics (Hin et al., 2023; Putri et al., 2018; Sutrisno, 2015). One effort to create fun learning and overcome misconceptions is to optimize the use of IT with the right goals.

Several studies that have been conducted regarding the use of IT in learning show that the use of technology associated with learning strategies can contribute to better learning outcomes (Lopez-Caudana et al., 2020), helping students with learning disabilities in mathematics (Lin, 2015), reducing anxiety in math methods courses (Orozco, 2022), as well as developing practices that enable them to learn mathematics collaboratively (da Silva et al., 2021). Capacity building for mathematics teachers using technology applications also shows good results in learning (Gurrea et al., 2022). Other research related to the use of IT in geometry material has also been carried out by various experts, which shows that augmented reality tools can create problematic situations for gaining academic success in teaching geometry (Rashevska et al., 2020), improving the way teaching geometry to students with disabilities or difficulties learning (Su et al., 2022), and discovering new and more valuable and complex theories to support geometry (Capone & Lanzara, 2019). Based on several existing studies, no research has been found on applying IT in learning to examine students' misconceptions and scientific attitudes toward geometry material. Therefore, this research needs to be done.

This study aims to describe elementary school teachers' misconceptions about geometry, the scientific attitudes of elementary school teachers in the process of learning geometry, and how elementary school teachers overcome misconceptions and optimize scientific attitudes learned from the role of IT.

METHOD

This study uses a qualitative method with a descriptive approach. The subjects of this study were elementary school teachers with a background in mathematics and non-mathematics who are members of the Teacher Working Group (KKG). Teachers who are the subject of this research are targeted at 100–200 people. The objects of this study are the misconceptions and scientific attitudes of elementary school teachers about learning geometry.

The data in this study were collected using test techniques. The question test is a written test given to research subjects using a Google Form. The test given was a questionnaire containing 19 questions, including six geometry questions, seven questions about the teacher's scientific attitude toward learning, and six questions about how the teacher optimizes the role of IT in learning geometry. The data obtained were then analyzed using qualitative data analysis techniques.

There are several aspects of scientific attitudes and indicators, according to Mangkunegara (2017), that will underlie this research, which is presented in Table 1.

Table 1. Aspects and Indicators of Scientific Attitude

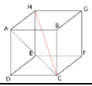
No	Aspect	Indicator
1	Curiosity	a. Enthusiastically looking for answers b. Ask questions related to the material being studied
2	Be critical	a. Find out the clarity of the question or statement b. Looking for true and accurate information
3	Invention and creativity	a. Using facts to base conclusions b. Changing opinions in response to facts
4	Objective	a. Report as is without manipulating data or information b. Make decisions based on facts
5	Open minded	a. Assume any conclusions are tentative b. Receive responses transparently
6	Based on evidence	a. Attitudes depend on facts and empirical data in making decisions b. Prioritize direct data sources

RESULTS AND DISCUSSION

Misconceptions of Elementary School Teachers in Learning Geometry

In the questionnaire distributed, there were six questions with four possible answers. Each question contained information about the misconceptions experienced by the teacher in learning geometry, namely questions number 13, 14, 15, 16, 17, and 18. Sample questions and answers are presented in the following table.

Table 2. Question Numbers 13 to 18

No.	Question
13	Pak Ahmad Hasan is a class III teacher at an elementary school. He said that examples of rectangular shapes in the classroom are desks, windows, and doors. As a teacher (mathematics or not), Mr. Ahmad Hasan's statement...
14	There is a block-shaped box, which is located on the floor. Then what is meant by the surface area of the box is...
15	 The volume of the cardboard box according to the picture above is...…
16	 What is meant by space diagonal and plane diagonal in the following cube framework are …
17	When you are a student or a teacher, the most difficult mathematics material to understand is...
18	It turns out that a cube has six sides, and a square has four. The side shape of a cube and a square is...

The selected answers to each question are distributed in the following table.

Table 3. Distribution of Answers to Questions Numbers 13 to 18

No	A	B	C	D	Expected answer	Expected answer Percentage
13	71	8	14	78	D	45,6%
14	65	21	65	20	C	38%
15	114	36	11	10	A	66,7%
16	68	88	9	6	A	39,8%
17	39	64	56	12	-	-
18	17	43	72	39	C	42,1%

The answer options in question number 13 are: a) true; b) wrong because it does not necessarily match; c) imprecise because rectangles are in many classes; and d) may add an explanation. The correct answer is d because tables, windows, and doors can be used as examples of rectangular shapes but added explanations so as not to cause misconceptions. The explanation in question can be in the form of a description of the part of the object that is rectangular, for example, door surfaces, window surfaces, and window frames in classrooms. Without this explanation, the example would be wrong because the objects around us have three dimensions, so they cannot be used as an example of a rectangle which is a flat shape. Therefore, answer a is incorrect, and the teacher who chooses a has a misconception. Teachers who chose b and c also experienced misconceptions because they thought the example was wrong. After all, it was not necessarily suitable, or there were many other examples. Indirectly, the teacher with options b and c considers the example mentioned by Mr. Ahmad Hasan to be a rectangle without the need for additional explanation.

The answer options for question 14 are a) 4 parts of the surface; b) 5 parts of the surface; c) 6 surface parts; and d) cannot be determined. The correct answer is c. The surface area is the total area of all sides of a figure. The block has six sides, so the box's surface area in the problem can be seen from the six parts of the surface. Teachers who choose b and d probably don't understand the concept of the surface area of a geometric shape. Teachers who choose an experience a misconception that might occur because they think a beam is the same as a rectangle with four sides.

The answer options for question number 15 are a) the inside of the box; b) inner cardboard paper; c) cardboard only; and d) difficult to determine. The correct answer is a. Volume is a calculation of how much space can be occupied in an object (Syahbana, 2013; Fitriasari, 2019). Therefore, the volume of the cardboard can be seen from how much space is available on the inside of the cardboard. Teachers who choose b and c experience misconceptions that can occur because the volume study is still shallow, so they think that volume is only calculated from the geometric side or what, in this case, is cardboard. In comparison, option d was chosen by the teacher, who did not understand the concept of geometric volume, so it was difficult to determine the answer to the question asked.

The answer options for question number 16 are a) CH and AC; b) AC and CH; c) BC and CH; and d) AC and AD. The correct answer is a. The space diagonal is a line connecting two non-planar facing corner points: AF, BD, CH, and EG. While the plane diagonal is a line that connects two corner points facing each other in one plane: AC, BD, AG, BH, FH, EG, DF, and CE. Misconceptions occur in teachers who choose b. Answer b is incorrect because the order is not following the question. Based on the analysis conducted by the researcher, this answer was chosen because the teacher considered the field diagonal to be the same as the space diagonal, so he did not pay attention to the order of the questions and matched the order in the answer options. Answers c and d were chosen by respondents who do not understand the concept of diagonals in geometric shapes. BC and AD are edges and do not include plane and space diagonals.

The answer options for question number 17 are a) algebra; b) geometry; c) arithmetic; and d) set. Based on the distribution of the answers chosen, it can be seen that geometry is the material that is most difficult for the teacher, who is the respondent, to understand. This can potentially cause misconceptions that occur not only in students but also in teachers. Misconceptions that occur allow the emergence of new theories that are inaccurate but are believed and taught from generation to generation.

The answer options for question number 18 are: a) they are the same because they are not much different; b) they differ in shape due to size; c) they have different dimensions because the form is not the same; and d) have the same origin but have different meanings. The correct answer is c. A cube is a three-dimensional shape with six plane-shaped sides, while a square is a two-dimensional plane shape with four line-shaped sides, so the sides of a cube and a square are clearly different. Teachers who choose a, b, and d experience misconceptions because they think the sides of a cube and a square are the same or differ only because of their size or meaning.

Misconceptions in elementary school teachers who are the subject of this study can be categorized as generalizing and specializing misconceptions. Generalization misconceptions can be seen in questions number 13, 15, 16, and 18. This misconception occurs because conclusions are drawn without sufficient reason, so the studies conducted are too shallow, leading to misunderstandings. Misconceptions of specialization can be seen in number 14, which occurs for excessive reasons in a concept so that they think the concept can be used in different situations. Misconceptions of calculation are almost not found in the results of this study.

The Scientific Attitude of Elementary School Teachers in the Geometry Learning Process

In the questionnaire distributed, seven questions contained information about the teacher's scientific attitude in learning geometry, namely questions 6, 7, 8, 9, 10, 11, and 12. Sample questions and scientific attitudes contained in each question were presented in the following table.

Table 4. Questions Numbers 6 to 12 and Their Scientific Attitudes

No.	Question	Scientific Attitude Content					
		A	B	C	D	E	F
6	If there is the latest (innovative) information, then…	✓	✓				
7	If I meet learning mathematics that is new to me, then...	✓	✓			✓	
8	Understand realistic mathematical theory (directly relevant to daily life), then...			✓			✓
9	Do an information search, the data used ...				✓		✓
10	In making decisions on learning, I try to...			✓	✓		✓
11	To gain understanding and confidence about new facts from geometric material, then...		✓	✓		✓	
12	Understanding geometry material that requires my IT to respond to …	✓				✓	

Information: A: curiosity; B: be critical; C: invention and creativity; D: objective; E: open-minded; F: based on evidence. The distribution of answers to questions number 6 to 12 is presented in the following table.

Table 5. Distribution of Answers to Questions Numbers 6 to 12

No	A	B	C	D	Expected answer	Expected answer Percentage
6	6	18	59	88	D	51,5%
7	42	24	26	79	D	46,2%
8	24	49	40	58	D	33,9%
9	23	108	40	0	B	63,2%
10	2	9	55	105	D	59,6%
11	21	41	55	54	C and D	63,7%
12	12	32	106	21	C	62%

The answer options for question number 6 are: a) I am too lazy to wait for the information to come to me; 2) I try to find the innovative information sober; 3) I try to find as much innovative information as possible; d) I seek such innovative information from various sources to understand. The most optimal scientific attitude can be seen in answer d. Curiosity and a critical attitude can be seen when the teacher enthusiastically seeks information from various sources to get correct and accurate information. In options b and c, the scientific attitude is visible but not too high, while in option a, the scientific attitude is not visible at all.

The answer options for question number 7 are: a) I study slowly without a target time; b) I learn slowly with a certain target time; c) I try to get to the stage of understanding myself; and d) I look for digital information to be understood. Option d shows the highest scientific attitude to this problem. Curiosity, a critical attitude, and an open mind can be seen when the teacher seeks information from various sources, including digital media, in order to understand this new information. In option a, there is a lack of curiosity, while a critical attitude and an open mind are not seen significantly. In option b, the scientific attitude is more visible because the teacher has a target time in finding the required information. In option c, there is a high level of curiosity and critical attitude, but they are less open-minded because they only try to do it themselves without trying to seek help from other sources.

The answer options for question number 8 are: a) if there are facts, it is still difficult for me to conclude; b) I am more inclined to adapt existing theory to make conclusions; c) I always draw conclusions based on theory; and d) the facts obtained are my basis for making conclusions using IT. Option d shows the highest scientific attitude because the teacher can make conclusions from existing facts and utilize IT. A scientific attitude is also seen in options b and c, but teachers with this option seem less creative because they only adhere to theory without utilizing IT. Whereas in option a, the scientific attitude is not visible because the teacher is unable to draw conclusions from the facts.

The answer options for question number 9 are: a) report data is processed according to existing expectations; b) the results of the original data are adjusted to become report data; c) reported as is but needs adjustments in important parts; and d) the results of the original data are processed with the weight according to the agreement. The most optimal scientific attitude is seen in option b. Meanwhile, in the other options, the scientific attitude is less than optimal because there is still the potential for data manipulation if it does not match the teacher's expectations.

The answer options for question number 10 are a) different from the facts, always benefit students; b) different from the facts, by applicable regulations; c) according to the facts, it always benefits students; and d) according to the facts, and according to the agreed rules. The scientific attitude is most visible in option d. In options a and b, the scientific attitude is less visible because the decision is different from the facts. In option c, decision-making that always benefits students can be inconsistent with the facts, so the scientific attitude to this option is also lacking.

The answer options for question number 11 are: a) based on experience; b) strived based on comparative literature; c) include IT that is relevant to the geometric concept in question; and d) provide concept reinforcement through relevant IT. Optimization of the scientific attitude is seen in options c and d because it utilizes IT to search for relevant literature and experience to the concept being explored. In option b, the scientific attitude is good enough, but it can still be improved with the application of IT. In option a, the scientific attitude is less visible because understanding the concept depends on experience without trying to find other, more relevant information.

The answer options for question number 12 are: a) never done; b) only as necessary; c) repeated while internalized; d) often done but not internalized. Option c shows the highest scientific attitude, which can be seen from the teacher's enthusiasm for understanding the material by utilizing IT while being internalized. Options b and d show a lack of scientific attitude because they only use IT as needed without trying to optimize its role. Option a indicates that the teacher does not have a scientific attitude because he never uses IT, even to understand geometric concepts that require IT.

How Elementary School Teachers Overcome Misconceptions and Optimize Scientific Attitudes Assess from the Role of IT

In the questionnaire distributed, six questions contained information about how the teacher overcame misconceptions and optimized his scientific attitude through the role of IT, namely questions number 1, 2, 3, 4, 5, and 19. Questions and answer options are presented in the following table.

Table 6. Questions and Answer Options Numbers 1, 2, 3, 4, 5, and 19

No	Questions	Answer options
1	If there are problems learning geometry/mathematics, I try to find information using IT:	a. Always b. Often c. Sometimes d. Never
2	If there is confusion in learning geometry/mathematics, what I do is...	a. Reflect on yourself; hopefully, there is an answer b. Trying alone, even though it's not finished c. Make a list of questions as material for discussion with friends d. I searched using the IT
3	The GeoGebra application clarifies the understanding of geometric/mathematical concepts …	a. I don't know about the Geogebra app at all. b. I've heard that the Geogebra app is great for geometry, but I'm being mediocre c. I can use the Geogebra application, but rarely in learning geometry/mathematics d. I often use the Geogebra application in learning geometry
4	Information about the clarity of my class's latest geometry/mathematics learning...	a. I didn't clearly follow b. I just follow the usual conventional c. I actively follow, but without IT assistance d. I'm ready to follow along and take advantage of IT
5	The accuracy of new information in learning mathematics …	a. I don't quite follow b. I'm just looking for information c. I followed the conventional as best I could d. I'm trying to find accurate information through the IT
19	With an independent curriculum, the project method is emphasized. Your response...	a. Useful for contextualizing material b. Not much understanding about the project in question c. Pessimistic things that are targeted will be achieved d. Other...

The distribution of answers to questions 1, 2, 3, 4, 5, and 19 can be seen in the following table.

Table 7. Distribution of Answers to Questions Numbers 1, 2, 3, 4, 5, and 19

No	A	B	C	D	Expected answer	Expected answer Percentage
1	111	0	56	4	A	64,9%
2	0	13	67	91	D	53,2%
3	123	13	25	10	D	5,8%
4	34	42	23	72	D	42,1%
5	15	38	40	78	D	45,6%
19	104	58	7	2	A	60,8%

In question number 1, it can be seen that most teachers have used IT well to overcome learning problems, as in question number 2. Unfortunately, many teachers still do not know and utilize the GeoGebra application in geometry learning, which can be seen from the distribution of answers to number 3. In question number 4, it can be seen that the ratio of teachers who prefer conventional media is more than those who use IT, as well as question number 5. In question number 19, more than half of the teachers who chose a can be categorized as teachers who understand the project method where IT is more dominant and give a positive response to it.

Based on the results of the research that has been analyzed, it turns out that misconceptions still occur when learning geometry in elementary schools. Misconceptions that occur can be categorized as generalization misconceptions and specialization misconceptions, both of which focus on drawing the wrong conclusions from a concept that is considered too general or too specific. This is in line with findings (Ay, 2017), which state that misconceptions stem from errors in understanding or interpreting concepts. Some of the causes of misconceptions in this study are explanations of the elements in spatial shapes that are not accompanied by examples and do not provide relevant comparisons between flat and spatial shapes (Ningsih et al., 2022).

The analysis results in this study indicate that the high scientific attitude of teachers is directly proportional to their use of IT. This means that teachers who used to use IT in learning have a higher scientific attitude than teachers who are not used to or are still reluctant to use IT. Therefore, maximizing the role of IT is a step that must be taken to overcome misconceptions about learning geometry and optimize the scientific attitude of elementary school teachers.

The role of IT that can be maximized can be in the form of using applications that help with calculations or visualization of abstract things in mathematics and information retrieval media, either through search engines or social media. This finding is in line with the opinions of Putrawangsa & Hasanah (2018) and Jupri et al. (2015), which state that technology functions as a medium for carrying out mathematical calculations, as a place for learning, as a medium for developing students' thinking power, as a medium for understanding student concepts, and as a tool to develop intuition and understand mathematical concepts.

CONCLUSIONS

Several conclusions can be drawn based on the results of the research that has been done. First, many elementary school teachers still experience misconceptions about learning geometry. Misconceptions that occur are categorized as generalization and specialization misconceptions. This misconception occurs due to obtaining accurate information or explaining incorrect and excessive concepts. Second, the teacher's scientific attitude influences the misconceptions experienced. Some teachers already have the expected scientific attitude; some still need to optimize their scientific attitude. Third, the role of IT can help calculate and visualize abstract things in learning and help teachers find the information needed to minimize misconceptions and optimize their scientific attitude.

The application of IT in the learning process shows good results for overcoming teachers' misconceptions and scientific attitudes, and it can be an option for teachers to be able to apply it with various IT-based learning media that attract students' learning interests. This study was limited to measuring teachers' misconceptions and scientific attitudes toward elementary school students' geometry material. Further research can examine other learning materials using IT so that the research results related to students' misconceptions and the teacher's scientific attitude can become a teacher's reference when applying it to the learning process.

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AUTHOR CONTRIBUTIONS STATEMENT

As the first author, BB served as the chief executive and research coordinator. NWM served as the implementing operator and research instrument. DF served as the maker of proposals, reports, and articles up to revision. ZR served as an instrument maker and validator search. HH served as a narrative designer, results, and discussion.

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