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Misconceptions about Science Learning Materials of Class V in Elementary Schools using A Diagnostic Instrument of Four-Tier Multiple Choice

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Abstrak

Sistem pendidikan Indonesia saat ini memerlukan penilaian terhadap peserta didik secara menyeluruh yang terangkum dalam tiga aspek besar, yaitu kognitif, psikomotorik, dan efektif. Penilaian dilakukan dalam rangka mengukur ketercapaian indikator pembelajaran yang diharapkan dan mengetahui kesulitan belajar. Kesulitan belajar dan miskonsepsi siswa harus diketahui oleh guru agar dapat diambil langkah yang tepat untuk mengatasinya], salah satunya dengan melakukan tes diagnostik. Penelitian bertujuan untuk menganalisis miskonsepsi materi IPA pada tema VI panas dan perpindahannya kelas V sekolah dasar. Penelitian ini dilakukan dengan pendekatan kualitatif. Metode pengumpulan data berupa tes diagnostik four-tier dan wawancara. Teknik pengambilan sampel menggunakan purposive sampling yaitu seluruh peserta didik kelas V SDN 1 Krasak Boyolali. Hasil penelitian menunjukkan bahwa miskonsepsi yang terjadi pada peserta didik memiliki rata-rata sebesar 29,33% dengan kategori rendah. Miskonsepsi terendah dengan persentase 23,32% terdapat pada subkonsep konduktor dan isolator. Miskonsepsi tertinggi terletak pada subkonsep perbedaan suhu dan panas dengan persentase 36,65%. Faktor penyebab miskonsepsi pada peserta didik berasal dari prakonsepsi yang salah, minat belajar rendah dan reasoning tidak sesuai.

Kata Kunci: *Miskonsepsi, Materi IPA, Panas dan Perpindahannya*

Abstract

The current Indonesian education system requires a comprehensive assessment of students which is summarized in three major aspects: cognitive, psychomotor, and affective. Assessments are carried out to measure the achievement of expected learning indicators and identify learning difficulties. Teachers must know their students' learning difficulties and misconceptions, so appropriate steps can be taken to overcome the problems. One of the solutions is carrying out diagnostic tests. This research aimed to analyze misconceptions about science learning materials in theme VI concerning heat and its transfer to class V of elementary schools. This research was conducted using a qualitative approach. The data collection method was a four-tier diagnostic test and interviews. The sampling technique used purposive sampling, namely all the fifth graders of public elementary school (SDN) 1 Krasak, Boyolali. The research results showed that the average misconception occurring among students was 29.33% which belonged to the low category. The lowest misconception with a percentage of 23.32% was in the sub-concept of conductors and insulators. The highest misconception was in the sub-concept of differences in temperature and heat with a percentage of 36.65%. Factors that caused misconceptions among students were wrong preconceptions, low interest in learning, and inappropriate reasoning.

Keywords: Misconceptions, Natural Science Materials, Heat and its Transfer

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1. INTRODUCTION

Students' interest in experimenting with various things is often associated with abstract scientific learning. One of the thematic scientific subjects that must be given at the elementary tier is natural sciences (science). The content of science lessons currently uses a scientific approach in the 2013 curriculum (Ilhami et al., 2019; Okmarisa, 2021). Science thematic learning places more emphasis on real experiences and discovery processes so that students are actively involved. The basis for science learning is in the form of interesting natural events as a means of learning to know nature by utilizing the surrounding

environment (Ilhami et al., & Sriyati, 2019). Abstract science lessons can be a difficult factor for students to understand the learning material and concepts given. One of the problems in Indonesian education is the lack of proper understanding of concepts. Understanding concepts in learning activities is one of the things that needs to be paid attention to by both students and educators because it is related to the processing of knowledge and learning outcomes. Understanding of concepts is provided during teaching and learning activities from various scientific reading reference sources to students in a precise and detailed manner so that educational success is achieved. Problems in understanding scientific concepts must be addressed immediately to improve understanding of the material and student learning outcomes (Soeharto et al., 2019; Suliyanah et al., 2018).

Misunderstanding concepts negatively impact oneself, especially academic achievement, and can prevent students from learning relevant material (Dewi, S. Z., & Ibrahim, 2019; Eshach et al., 2018; Suliyanah et al., 2018). Initial concepts that are wrong or conflict with scientific concepts continue to happen when science teaching and learning activities are completed (Eshach et al., 2018; Ladd & Sorensen, 2017). Students who experience misconceptions can reject ideas and even find it difficult to accept new scientific concepts because they are resistant and it prevents them from achieving a comprehensive understanding of the material. Students can understand concepts well if they have basic experience and broad insight (Dewi & Ibrahim, 2019). Student learning outcomes are obtained from experiences during learning (Ladd & Sorensen, 2017). Misunderstanding of concepts must be immediately followed up and analyzed to improve understanding.

Based on the results of interviews during the learning process at SDN 1 Krasak Boyolali with the class V homeroom teacher, one of the problems experienced by the students was difficulty understanding concepts, especially science learning materials. Difficulty in understanding concepts occurs because students are afraid to ask questions, the initial understanding formed by students is not in line with existing concepts and the teacher delivers material in language that is difficult to understand, especially the use of scientific terms. The teacher revealed that 11 students scored below the Minimum Criteria of Mastery Learning (KKM) of 70 in the science subject VI theme VI concerning hot material and transfers because they did not understand the concepts given optimally and had limitations in linking their initial understanding with the material given.

The results of observation activities in the preliminary study during the learning process stated that there were two factors causing difficulties in understanding the material originating from students and teachers. Factors originating from students include some students having an inaccurate initial understanding of the given materials, students having difficulty understanding scientific terms in science materials, especially heat and transfer materials, many concepts that have to be memorized, students' inability to use textbooks optimally, students' feeling afraid to ask questions or express opinions, and not focus when the teacher delivers teaching materials. Factors originating from teachers are caused by the application of learning methods that are less interesting and when delivering materials, teachers use language too complicated language, so it is difficult for students to understand.

One instrument that can be used to analyze students' misconceptions is by carrying out diagnostic tests. The use of diagnostic tests at the beginning and end of learning can help teachers find students' misconceptions about the materials being studied (Gurel et al., 2015; Schultz et al., 2017). A good diagnostic test can certainly provide an accurate picture of the misconceptions experienced by students based on information about the errors they make. Good diagnostic questions not only show that students do not understand certain parts of the material but can also show students' way of thinking in answering the questions given even if the answer is wrong (Fadllan et al., 2019; Gurel et al., 2015; Sholihat et al., 2017). Misconceptions diagnostic tests are presented in various forms, for example, interviews, open

questions and essays, multiple-choice tests, and graded choice tests (Iswana et al., 2016; Maison et al., 2021). Apart from that, multiple choice also has the weakness of not being able to differentiate between the correct answer for the right reason and the wrong reason. The development of multitier multiple-choice tests aims to compensate for the shortcomings or completeness of multiple-choice tests in general (Diani et al., 2019).

This research is important to determine the existence of misconceptions in elementary school students and minimize the occurrence of conceptual errors through a four-tier multiple choice diagnostic test. Students feel that they have not mastered science learning material, resulting in an inaccurate initial understanding of the material provided and giving rise to misconceptions. Four Tier Multiple Choice is specifically designed to detect misconceptions. Compared to other types of assessment instruments, such as traditional multiple choice, Four Tier Multiple Choice provides an additional layer by separating student responses into four levels, allowing for more in-depth and focused analysis. This helps in adjusting learning strategies and improving the curriculum according to the needs and context of the students concerned, especially regarding hot material and its transfer. Not only does it measure whether students can answer right or wrong, but also see the extent of their understanding of key concepts. Based on this, the study aims to analyze the misconceptions of science material on theme VI heat and its transfer in grade V elementary schools.

2. METHODS

This research used qualitative research with descriptive methods. Qualitative research is factual research used to obtain a comprehensive understanding of the meaning and experiences of developing subjects (Sugiyono, 2015). The qualitative data obtained in this research was taken directly in the field and then analyzed and described according to the existing reality regarding misconceptions in science materials concerning heat and its transfer to theme VI of class V students at SDN 1 Krasak Boyolali.

The data collection technique used by this researcher is a test using the Four Tier Multiple Choice instrument. Primary data is informational data obtained directly from researchers regarding various questions related to research (Sugiyono, 2015). This research used data derived from four-tier diagnostic tests. The four-tier diagnostic test consisted of 25 questions in the form of scores. The sampling technique in this research was purposive sampling, meaning that sampling was based on the desire to obtain accurate data related to existing problems according to certain criteria. The considerations made in this research are in line with research needs, namely to find out the existence of misconceptions among all 16 fifth graders at SDN 1 Krasak Boyolali. The purpose of selecting the students was because there had already been science content studied in thematic learning, problems were found in line with the research topic related to misconceptions, and the learning outcomes of the fifth graders in science materials, especially theme VI, did not meet the minimum completeness criteria score compared to other classes.

The summarized data help researchers to carry out in-depth data analysis more easily. The reduced data in this research were data from the results of the four-tier diagnostic test and data from interviews with the fifth-graders at SDN 1 Krasak Boyolali. Then the data was sorted to obtain the main data related to misconceptions about science material in theme VI for class V of elementary school.

Data analysis from the four-tier diagnostic test was first grouped based on the categories of being unable to code, being unable to understand the concept, misconceptions, and understanding the concept. The error category was that the first-tier answer was wrong but the reason at the third tier was correct and the second-tier belief was in the form of being sure or not sure while the belief in the reason for the answer at the fourth tier is being sure.

The category of students who do not understand the concept was if the answer is wrong or right in the first and third tiers but the belief in the second and fourth tiers is in the form of sure or not sure. The misconception category is if students give correct answers at the first tier and are not sure at the second tier but the reasons given are wrong at the third tier and are sure of the reasons at the fourth tier. The category of understanding the concept is correct in answering the first and third tiers and then being confident in choosing the answer and the reasons for the second and fourth tiers. Based on the description of the statement above, the combination of students' answers can be seen in Table 1.

Table 1. Grouping of Four-tier Diagnostic Test Answers

Category	Answers			
	First Tier	**Second Tier**	**Third Tier**	**Fourth Tier**
Error/Being Unable to Code	Wrong	Sure	Correct	Sure
	Wrong	Doubtful	Correct	Sure
Being Unable to Understand Concepts	Wrong	Doubtful	Wrong	Sure
	Correct	Sure	Correct	Doubtful
	Correct	Sure	Wrong	Doubtful
	Correct	Doubtful	Correct	Sure
	Correct	Doubtful	Correct	Doubtful
	Correct	Doubtful	Wrong	Doubtful
	Wrong	Sure	Correct	Doubtful
	Wrong	Sure	Wrong	Doubtful
	Wrong	Doubtful	Correct	Doubtful
	Wrong	Doubtful	Wrong	Doubtful
Misconceptions	Correct	Sure	Wrong	Sure
	Correct	Doubtful	Wrong	Sure
	Wrong	Sure	Wrong	Sure
Understanding Concepts	Correct	Sure	Correct	Sure

The calculation of the percentage of student scores on the four-tier diagnostic test uses the following equation (Annisa et al., 2019). The percentage of misconceptions is categorized as low when it reaches 0% - 30%. Misconceptions are categorized as moderate when they have a value of 31% - 60%. The misconception category is said to be high if the percentage reaches 61% - 100%.

3. RESULTS AND DISCUSSION

Result

This research used a four-tier diagnostic test with 20 questions which had been validated by experts according to standard competency and indicators of science materials in theme VI, heat and its transfer. The basic competency in science material for theme VI, heat and its transfer, was to apply the concept of heat transfer in everyday life. The sub-concept of science material in theme VI, heat and its transfer, included sources of heat energy, differences in temperature and heat, changes due to temperature changes, heat transfer, conductors, and insulators. . Four-tier Diagnostic Test Grid on Science Material Theme VI Concerning Heat and Its Transfer showed in Table 2.

Table 2. Four-tier Diagnostic Test Grid on Science Material Theme VI Concerning Heat and its Transfer

No.	Sub-Concepts	Total of Questions	Question Number
1	Source of Heat Energy	4	1, 2, 3, 4
2	Differences in Temperature and Heat	4	5, 6, 7, 8
3	Effects of Temperature Changes	4	9, 10, 11, 12
4	Heat Transfer	4	13, 14, 15, 16
5	Conductors and Insulators	4	17, 18, 19, 20

The sub-concept of heat energy sources emphasized photosynthesis material which utilized sunlight as an energy source at numbers 1, 2, 3, and 4. Based on the results of students' answers, the highest percentage of misconceptions occurred in questions number 1 and 3 at 33.3 %. The results of the diagnostic test for the heat energy source sub-material in Figure 1.

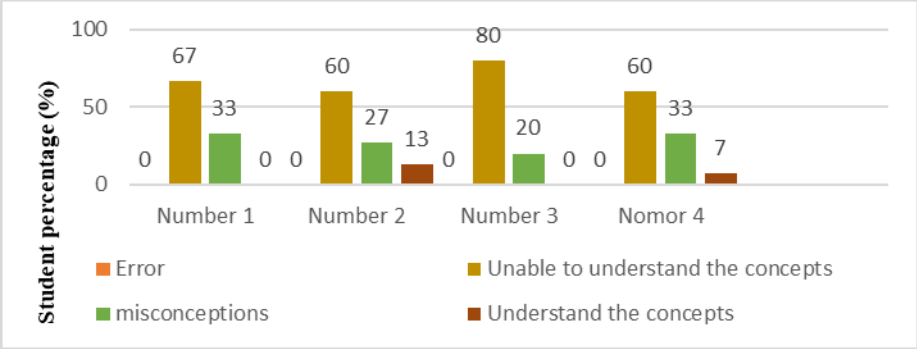

Figure 1. The Percentage of Diagnostic Test Answer Results on the Sub-Concept of Heat Energy Source

Based on Figure 1, it can be concluded that for question number 1 on the diagnostic test, 33.3% of students experienced misconceptions, and 66.7% of students did not understand the concept. The sub-concepts of temperature and heat differences were located in numbers 5, 6, 7, and 8. Based on the results of students' answers, the highest percentage of misconceptions occurred in questions number 5 and 7 with 40%. The results of the diagnostic test for sub-material temperature and heat differences showed in Figure 2.

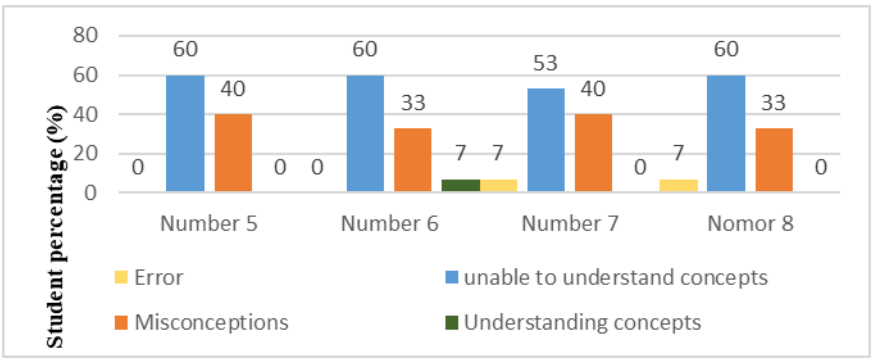

Figure 2. The Percentage of Four-Tier Diagnostic Test Answer Results on the Sub-Concept of Differences in Temperature and Heat

Question number 5 based on the results of the analysis of answers in Figure 2 has a percentage of 40% of students who experienced misconceptions and 60% of students who did

not understand the concept. As a result, there were no students who understood the concepts completely and experienced errors. The sub-concept of differences that occur due to temperature changes were located in numbers 9, 10, 11, and 12. Based on the results of students' answers, the highest percentage of misconceptions occurred in question number 11 with 46.7%. The results of sub-material diagnostic tests due to temperature differences in Figure 3.

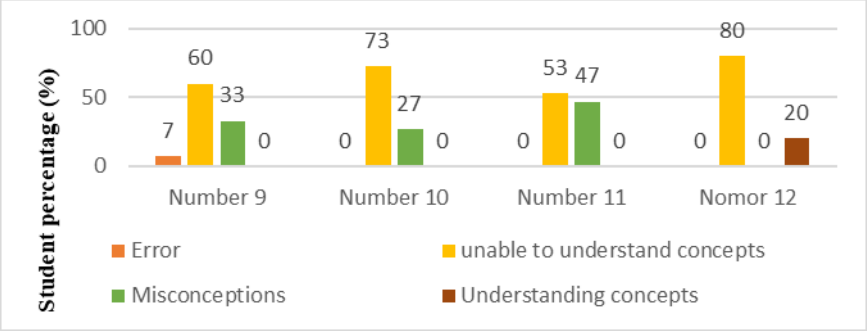

Figure 3. The Percentage of Diagnostic Test Answer Results on the Sub-Concept of Temperature Change

Question number 9 based on the answers in Figure 3 had a percentage value of 33.3% of students who experienced misconceptions, 60% of students who did not understand the concept, and 6.7% of students who experienced errors. The results of the answers to the sub-concept of temperature changes number 9 did not show that students understood the concept as a whole. The sub-concepts of heat transfer were located in numbers 13, 14, 15, and 16. Based on the results of students' answers, the highest percentage of misconceptions occurred in question number 16 with 40%. The results of the heat transfer sub-material diagnostic test in Figure 4.

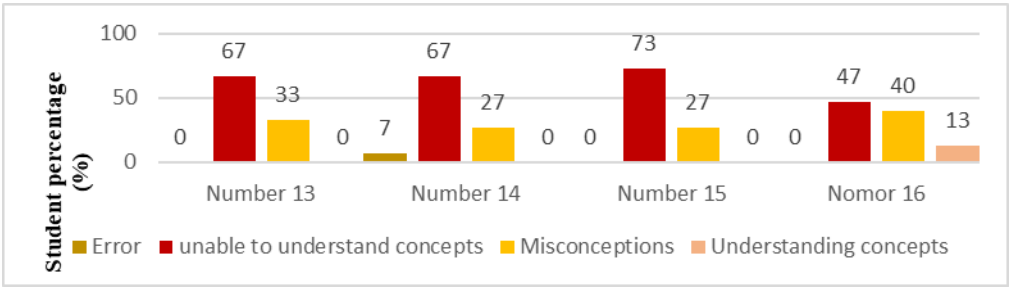

Figure 4. The Percentage of Diagnostic Test Answer Results on the Sub-Concept of Heat Transfer

Question number 13 based on the answers in Figure 4 had a percentage value of 33.3% of students who experienced misconceptions and 66.7% of students who did not understand the concept. The results of answers to the sub-concept of heat transfer number 13 did not show that students understood the concept completely and experienced error answers. The sub-concepts of conductors and insulators were located at numbers 17, 18, 19 and 20. Based on the results of students' answers, the highest percentage of misconceptions occurred in question number 20 with 40%. The results of the heat transfer sub-material diagnostic test showed in Figure 5.

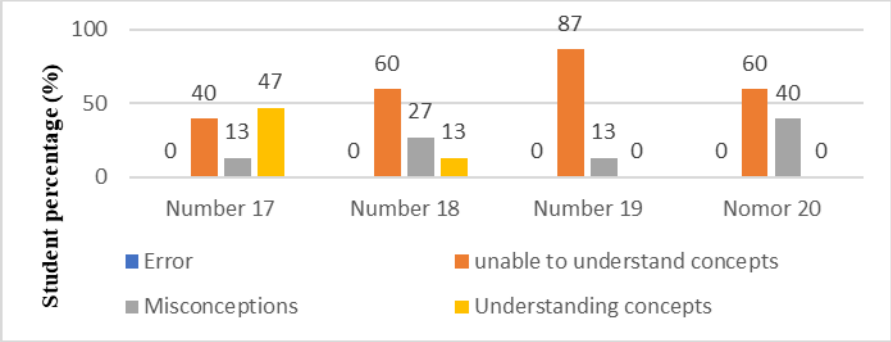

Figure 5. The Percentage of Diagnostic Test Answer Results on the Sub-Concepts of Conductors and Insulators

Question number 17 based on the answers in Figure 5 had a percentage value of 13.3% of students who experienced misconceptions, 40% of students who did not understand the concept, and 46.7% of students who understood the concept as a whole. The results of the answers in data number 17 did not find any students experiencing error answers. Based on the analysis of the results of the diagnostic test answers above, it can be seen that the percentage table for each question item on heat and its transfer in Table 3.

Table 3. The Percentage of Students' Understanding of Each Question Item

No.	Sub-Concept of Materials	Question Number	Percentage (%)			
			Error	Being Unable to Understand the Concept	Misconceptions	Understanding the Concept
1	Thermal Energy Sources	1	0.00	66.7	33.3	0.00
		2	0.00	60.0	26.7	13.3
		3	0.00	80.0	20.0	0.00
		4	0.00	60.0	33.3	6.70
	Average		**0.00**	**66.67**	**28.32**	**5.00**
2	Differences in Temperature and Heat	5	0.00	60.0	40.0	0.00
		6	0.00	60.0	33.3	6.70
		7	6.70	53.3	40.0	0.00
		8	6.70	60.0	33.3	0.00
	Average		**3.35**	**58.32**	**36.65**	**1.67**
3	Changes Due to Temperature Changes	9	6.70	60.0	33.3	0.00
		10	0.00	73.3	26.7	0.00
		11	0.00	53.3	46.7	0.00
		12	0.00	80.0	0.00	20.0
	Average		**1.67**	**66.65**	**26.67**	**5.00**
4	Heat Transfer	13	0.00	66.7	33.3	0.00
		14	6.70	66.7	26.7	0.00
		15	0.00	73.3	26.7	0.00
		16	0.00	46.7	40.0	13.3
	Average		**1.67**	**63.35**	**31.67**	**3.32**
5	Conductors and	17	0.00	40.0	13.3	46.7
		18	0.00	60.0	26.7	13.3

No.	Sub-Concept of Materials	Question Number	Percentage (%)			
			Error	Being Unable to Understand the Concept	Misconceptions	Understanding the Concept
	Insulators	19	0.00	86.7	13.3	0.00
		20	0.00	60.0	40.0	0.00
Average			**0.00**	**61.67**	**23.32**	**15.00**
TOTAL			**1.34**	**63.34**	**29.33**	**6.00**

Based on Table 3 above, students who experienced misconceptions had an average score of 29.33%, which was still relatively low and could be improved. Based on the figure and table above, the misconceptions experienced by students occurred in all sub-concepts of heat material and its transfer. Differences in misconceptions can be categorized as low, moderate, or high according to the percentage.

The most common misconceptions occurred in the sub-concept of temperature and heat differences, amounting to 36.65%, which belonged to the moderate category. The lowest percentage of misconceptions occurred in the sub-concept of conductors and insulators. Based on this, it can be concluded that the tier of misconceptions that occurred among the fifth-graders at SDN 1 Krasak Boyolali was still classified as moderate and could be improved.

Discussions

Based on the research data from diagnostic tests and interviews, students experienced misconceptions in all sub-concepts of the materials. The data obtained showed that 29.33% of students experienced misconceptions, 6% understood the concept, 63.34% did not understand the concept and 1.34% had errors. Based on data analysis, the most misconceptions were found in questions number 6 and 8, sub-concept of differences in temperature and heat, as much as 53.3% were in the moderate category. Most students could not differentiate between expansion and contraction.

Factors causing misconceptions could be identified during interviews with students. Most students who experienced misconceptions were caused by experiences in daily life that formed their thoughts outside of existing concepts (Kamilah & Suwarna, 2019; Savira et al., 2019). Students with incorrect preconceptions regarding the sub-concept of the difference between temperature and heat had the initial concept that temperature and heat were the same. The reason for forming this wrong concept was that when measuring body temperature using a thermometer, the result was how hot the body temperature was. Misconceptions regarding the difference in temperature and heat could still be corrected because it was still classified as moderate (Apriadi & Redhana, 2019; Samsudin & M, 2017). False preconceptions in students were related to Vygotsky's learning theory which stated that concepts that were built and developed came from observing the surrounding environment. Students' wrong preconceptions could be identified by doing a pretest before the material was given and conveying the fact in the form of a statement or video that temperature and heat were two different things.

Misconceptions in the sub-main source of heat energy were still relatively low with a percentage of 28.32% and were easy to improve by providing motivation. Difficulties experienced by students could be caused by several factors, including learning strategies presented by teachers, students' learning habits, low learning intensity, students' fear of certain topics, and lack of learning resources (Etobro & Fabinu, 2017; Ichsan & Mulyani,

2018). Students who had difficulty understanding and interpreting concepts interpreted the concepts they learned themselves, giving rise to misconceptions for themselves (Kamilah & Suwarna, 2019; Savira et al., 2019). Misconceptions could occur due to receiving wrong information, integration errors, and perceptions that were not in line with scientific principles (Duda et al., 2020; Kumandaş et al., 2018; Wahyono & Susetyorini, 2021). Misconceptions could cause delays in the transfer of new information related to the concepts that students learned (Rukmana, 2017). Misconceptions could form from a mismatch between the knowledge students had and the theory they were studying. When students learned a theory in class, they had different prejudices about the theory they were studying because of past experiences (Duda et al., 2020; Mulyani, 2018).

Student misconceptions occur due to students' experiences in everyday life, reading sources used by students, and information from teachers or tutors and friends when students study (Bekkink et al., 2016; Firdaus et al., 2021; Syamsiar, 2021). Experiences in everyday life are used as students' way of thinking in understanding a concept and often language differences cause students to experience misconceptions when learning (Jauhariyah et al., 2018). Learning resources that are difficult to understand because they are complex and abstract cause students to experience misconceptions (Halim et al., 2018) . Teacher errors in explaining concepts to students or teachers' ignorance of the concepts presented to students also cause misconceptions among students (Istiyani et al., 2018; Tahya & Kayadoe, 2020; Widarti et al., 2017). Peers who directly provide information without confirmation and follow-up regarding the concepts being studied can cause students to experience misconceptions (Duda et al., 2020)

Misconceptions are not only caused by students, but are also caused by many things such as books, teachers, and the environment (Maison et al., 2021; Syamsiar, A. A., 2021). The learning model used also influences the occurrence of misconceptions (Widodo, 2019). The use of learning media that is less relevant also affects the success of transferring information to students. Misunderstandings and lack of knowledge are also caused by students' inability to summarize the information they obtain to build concepts independently. Students are unable to interpret the information obtained during learning, which causes misconceptions (Istiyani et al., 2018; Waluyo et al., 2019). Students are unable to explain the concepts they have learned and give unclear responses to questions because of students' low confidence in their answers

The results of this study support previous research showing that the FourTier Multiple Choice test is treated as an instrument to measure student learning progress. Diagnostic information is needed for teachers in developing prospective learning strategies and evaluating science learning (Kaltakci-Gurel, et al., 2017; Laliyo et al., 2021; Zhao et al., 2023). The four-tier multiple-choice test instrument developed can identify students' conception profiles because it can differentiate between students who understand the concept, do not understand the concept, and those who experience misconceptions. The theoretical implications of this research are to provide a real picture regarding the misconceptions experienced by students in the science material on theme VI (heat and its transfer) through four-tier diagnostic tests and interviews so that corrections can be made immediately according to the cause. The practical implications of the results of this research can be used as a reference for teachers and prospective teachers as prevention and treatment efforts to minimize the occurrence of misconceptions in students based on the causes.

4. CONCLUSION

Based on the analysis of misconception data on science theme V (heat and its transfer), it can be concluded that fifth grade students of SDN 1 Krasak Boyolali experience

misconceptions on science theme VI. Misconceptions that occur are in the subconcept of heat energy sources in the low category. Misconceptions on the subconcept of temperature differences and heat are included in the moderate category. Misconceptions on the subconcept of changes due to temperature changes are included in the low category. The subconcept of heat transfer experiences misconceptions in the moderate category. Misconceptions on the subconcept of conductors and insulators with the smallest percentage and are included in the low category. Based on the results of the analysis and calculation of the four-level diagnostic test data, the misconception with the lowest percentage is in the subconcept of conductors and insulators. The factors causing misconceptions in students come from wrong preconceptions, low interest in learning, and inappropriate reasoning.

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