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IDENTIFICATION OF STUDENTS' CONCEPTUAL UNDERSTANDING OF TEMPERATURE AND HEAT MATERIAL

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Abstract :
The purpose of this study was to determine the conceptual understanding of eleventh-grade students in Science-Three at Senior High School 8 Malang on the topic of temperature and heat. The study used a survey method with a multiple-choice question instrument that had been tested. The data analysis technique used was quantitative descriptive analysis based on the percentage of students' level of understanding. The questions were analyzed by the level of difficulty. The results of the study indicated that students' conceptual understanding score was 45.4%. It can be concluded that eleventh-grade students in Science-Three at Senior High School 8 Malang have a moderate level of understanding of the concepts of temperature and heat. The study revealed that many students had misconceptions about heat capacity and heat equilibrium. This study revealed that many students have misconceptions about heat capacity and heat equilibrium indicating that students do not fully understand this material. The author analyzed students' responses to questions categorized as difficult to determine the extent of their conceptual understanding when answering.

Keywords: Conceptual understanding, Heat, Temperature

INTRODUCTION

One of the sciences that studies natural phenomena and presents with various basic concepts in the form of formulas and laws is physics. Physics in its concept studies and analyzes the quantitative understanding of natural phenomena, the properties of substances and their implementation (Hara et al., 2023). The facts in the field show that physics is considered a difficult and formulaic subject where many students only memorize formulas. The subject that is dubbed as a subject that students do not like is physics (Istiqomah et al., 2017). The lack of student interest in physics lessons is because physics is considered a difficult subject. Physics is a subject that is classified as difficult and very challenging for students to learn (Jannah & Haryadi, 2020). In fact, physics formulas do not need to be memorized but only the concept needs to be understood.

One of the abilities required in physics is the ability to understand concepts. When students truly grasp a physics concept, they don't just memorize formulas but comprehend the meaning of the concept. Therefore, when faced with a problem they can solve it because they genuinely understand the concept.

A concept is the basis or theory of a material derived from logical thinking. It is the result of thinking expressed by a definition, law or theory (Azizah et al., 2020). Understanding concepts is essential for abstract ideas in mathematics, classifying objects based on concepts, and providing examples and non-examples to clearly understand the concept (Pratiwi, 2022). Understanding concepts involves correct and precise thinking about abstract ideas so that others can comprehend them clearly. In physics, there is a relationship between different concepts. The significance of understanding concepts in physics lies in the interconnection between various concepts. Moreover, understanding physics is crucial for solving real-life problems. Physics plays a vital role in problem analysis, solution planning, and implementation (Mustofa, 2021). To address everyday challenges, having a solid grasp of basic concepts and ideas is essential. Your ideas must align with scientific concepts accurately. A correct understanding of scientific concepts serves as the foundation for learning other scientific concepts (Ni'mah et al., 2019).

In reality, many students experience conceptual errors due to their lack of understanding. However, the current problem is weak conceptual understanding which has fatal consequences for students in grasping certain materials (Risqa et al., 2021). If students' ability to understand physics concepts is low, it will affect their learning outcomes. The ability to understand concepts is an absolute requirement for success in physics learning (Febrianti et al., 2019). Therefore, in physics learning, educators must ensure that students not only memorize formulas but also understand physics concepts and relate them to other concepts so that physics learning can be successful and of high quality.

Physics is a branch of science that deals with temperature and heat materials that we often encounter in real life. This concept is one of the most common physics concepts in everyday life, so it is important for students to understand it (Silaban & Utari, 2015). Activities related to the concepts of temperature and heat are often encountered in everyday life, such as sunbathing and boiling water, and are widely used in increasingly sophisticated technological developments (Rochaenah & Linuwih, 2024). Understanding macroscopic physics involves understanding real-life events (Priyadi et al., 2019). When students grasp physics concepts from natural phenomena, they can solve problems in their daily lives. Learning through examples of daily activities related to the explained material can help students apply their knowledge effectively (Hidayat et al., 2022). Therefore, with a good and accurate understanding of the concept, all problems can be solved correctly.

Based on the results of previous studies, students' conceptual understanding scores still tend to be low (Taqwa et al., 2019). Previous research by Mustofa (2021) revealed several reasons for students' lack of understanding of temperature and heat material. First, the material is abstract, making it difficult for students to understand. Second, the concept of heat involves many supporting factors that are interconnected, requiring students to understand each factor. Third, students' understanding from real-life experiences may conflict with the concepts understood by experts.

This lack of understanding can hinder students' ability to apply their knowledge in practical situations and negatively impact their academic performance in physics (Said & Ishaq, 2024). Research by Yuliana et al. (2023) states that, on average, students have difficulty with several sub-topics, including the concept of specific heat, temperature, expansion, and the effect of heat on changes in temperature and phase. Another study by Widia Linta Nurjanah et al. (2024) revealed that students' understanding of the concept of heat propagation was still low. Research by Syahratinnur et al. (2023) revealed a misconception rate of 38.93% caused by one's own thoughts. The physics concept that is difficult for students is the question item on the concept of heat and temperature, while the physics concept that is perceived as easy is changes in state (Intisavira et al., 2023). Thus, it is concluded that Indonesian students do not yet have a complete understanding of the concept of temperature and heat. The results of the study are the basis for developing research in identifying misconceptions in students regarding this material.

This study aims to determine the level of understanding of the concepts of temperature and heat materials among eleventh-grade students in Science-Three at Senior High School 8 Malang. The study was conducted to identify the extent to which students' conceptual understanding can be used as an evaluation by physics educators and researchers so that the quality of physics learning can improve in the future. Educators can assess students, by giving them questions. Questions to measure analytical skills (C4) can be solved by considering the ability to divide or connect with several concepts (Nafi'ah et al., 2019). Therefore, by giving students questions, it can be used to see to what extent students understand the physics concept related to temperature and heat material where each concept is involved

with each other. The authors analyzed students' responses to questions categorized as difficult to determine the extent of their conceptual understanding when answering.

RESEARCH METHOD

Types of Research

This research is quantitative study with a mixed method approach, specifically descriptive quantitative using a survey method to assess students' conceptual understanding. The study was conducted at Senior High School 8 Malang.

Instruments and Data Collection Techniques

Data collection involved providing questions to 26 eleventh-grade students in Science-Three at Senior High School 8 Malang. Respondents were given a link to access the questions and had 60 minutes to work on them individually. The questionnaire consisted of 10 multiple-choice questions with explanations, administered through Google Form. The researcher utilized a question naire adapted from Wulandari et al. (2018) and instruments developed by Franklin (1992) and Kamcharean & Wattanakasiwich (2016), as well as instruments adapted from Ni'mah et al. (2019) and Taqwa et al. (2019). The questionnaire had been previously validated and tested for reliability.

Data Analysis Techniques

The data collected included quantitative data from multiple-choice scores and qualitative data from the explanations provided for each question. The analysis conducted was descriptive quantitative, focusing on analyzing students' multiple-choice scores to determine their understanding of the concept of temperature and heat. Additionally, the explanations provided by students for each question were analyzed to understand their thought processes.

In determining the percentage of students' understanding of the concept, researchers use categories from several levels listed in Table 1 sourced from (Sari et al., 2017).

Table 1. Percentage of Students' Concept Understanding Level

No.	Concept Understanding Level	Category
1.	$0\% \leq x \leq 30\%$	Low
2.	$30\% \leq x \leq 60\%$	Medium
3.	$60\% \leq x \leq 100\%$	High

In this paper, the author will discuss questions that are considered difficult. The calculation of the level of difficulty can be formulated as:

$$P = \frac{B}{JS} \quad (1)$$

Where P is the difficulty index, B is the number of students who answered the question correctly, and JS is the total number of respondents.

The level of difficulty of the questions can be categorized in Table 2.

Table 2. Criteria for Question Difficulty Level

Question Difficulty Level	Category
0,71 – 1,00	Easy
0,31 – 0,70	Medium
0,00 – 0,30	Difficult

Research Procedures

The research procedure includes data collection consisting of multiple-choice questions via the Google Form link. After the data is collected, it will be analyzed quantitatively and qualitatively to determine the level of understanding of the concept of temperature and heat material. The data will

be analyzed by examining the conceptual understanding score of each question. The questions that most students answered incorrectly will be analyzed for their level of difficulty. Questions classified as difficult will then be the focus of discussion.

RESULTS AND DISCUSSION

The conceptual understanding of eleventh-grade science-three students at Senior High School 8 Malang regarding the material of temperature and heat is classified as moderate. The data on students' conceptual understanding scores are shown in Table 3.

Table 3. Number of students who chose the correct option

Question Number	Number of Students Who Selected the Correct Option
1	19 (73,1%)
2	9 (34,6%)
3	10 (38,5%)
4	5 (19,2%)
5	18 (69,2%)
6	18 (69,2%)
7	13 (50,0%)
8	3 (11,5%)
9	17 (65,4%)
10	6 (23,1%)
The average	45,4%

In answering the questions, the score for understanding the concept of temperature and heat was obtained in the moderate category. The average student score only reached 45.4% (the average of all students who chose the correct option from 10 questions).

Misunderstanding the concept of temperature and heat can be identified from the distribution of student answers for each question. In several question numbers, namely questions 2, 4, 8, and 10, most students chose incorrect answers.

The existence of incorrect answers is due to the lack of student understanding and can also be caused by the criteria for questions that are classified as difficult.

From equation (1) and by examining Table 2, the criteria for the level of difficulty of each question can be presented in Table 4.

Table 4. Analysis of Difficulty Level of Question Items

Question Number	Number of Students Who Selected the Correct Option	Difficulty Index Value	Information
1	19	0,73	Easy
2	9	0,35	Medium
3	10	0,38	Medium
4	5	0,19	Difficult
5	18	0,69	Medium
6	18	0,69	Medium
7	13	0,50	Medium
8	3	0,12	Difficult
9	17	0,65	Medium
10	6	0,23	Difficult

Based on Table 4, the questions that fall into the difficult category are items numbers 4, 8, and 10. Therefore, the researcher will focus on discussing the level of students' conceptual understanding of these three questions.

The distribution of student answer option choices for Question Number 4 is presented in Table 5.

Table 5. Number of Student Answers for Number 4

Answer Options	The Number of Students
A	7 (26,9%)
B	5 (19,2%)
C	4 (15,4%)
D	5 (19,2%)
E*	5 (19,2%)

In question number 4, students were asked to determine the correct statement related to factors that affect heat capacity. The question statement was based on the definition of heat capacity. However, the choices made by students in selecting answers indicate that they still do not fully grasp the concept of heat capacity.

Students who selected options A and D linked the problem to the equation $C = \frac{Q}{\Delta T}$. They believed that heat capacity is directly proportional to Q and inversely proportional to ΔT. This suggests that students are simply memorizing formulas without truly understanding the underlying concepts (Prahestiningtyas & Sulisworo, 2022).

The distribution of student answers for question number 8 is shown in Table 6.

Table 6. Number of Student Answers for Number 8

Answer Options	The Number of Students
A	2 (7,7%)
B*	3 (11,5%)
C	15 (57,7%)
D	3 (11,5%)
E	3 (11,5%)

In question number 8, students are asked to determine the correct statement regarding the concept of thermal equilibrium, specifically the temperature of flour, nails, and water when placed in an oven heated to 60°C (140°F) and left for an extended period. Based on Table 6, the student responses indicate a lack of understanding of thermal equilibrium.

Many students incorrectly believe that the temperature of the nail will exceed 60°C due to their conductivity, while the flour, being a poor conductor, will have a lower temperature.

The distribution of student responses for question 10 is shown in Table 7.

Table 7. Number of Student Answers for Number 10

Answer Options	The Number of Students
A	6 (23,1%)
B*	6 (23,1%)
C	7 (26,9%)
D	6 (23,1%)
E	1 (3,8%)

In question number 10, similar to question number 8, the concept of thermal equilibrium is discussed. Students are required to determine the temperature comparison of wooden, metal, and plastic bowls of the same size placed on the kitchen table overnight with a room temperature of 75° F throughout the time. Based on Table 7, the student options show that students still do not grasp the

concept of thermal equilibrium accurately. Students seem to have similar misconceptions as in question 8. Students selecting options C and D assume that the metal bowl has a higher temperature than the other two bowls because metal is a conductor that transfers heat faster.

Based on the results of the analysis of students' answers to the three difficult questions, it can be concluded that many students have misunderstandings about heat capacity and heat equilibrium.

Research by Listyaningrum & Widodo (2024) stated that the effect of size value ranges from 0.30 to 0.72, which means it is in the moderate category for temperature and heat materials. Interview research conducted by Apriyanti et al. (2024) revealed that there were nine misconceptions held by students, which fell into the moderate category, accounting for 63.85%. Misconceptions about temperature and heat often occur in the concepts of object size, changes in state, Black's Principle phenomena, and heat transfer processes (Sofianto & Irawati, 2020). Meanwhile, research by Suhaila et al. (2024) revealed that student misconceptions occurred in the sub topics of temperature, expansion, heat radiation, specific heat, heat exchange, heat transfer, and states of matter.

The limitation of this study is that interviews were not conducted, so the researcher did not delve deeply into students' perceptions when answering questions on the material on temperature and heat. Interviews can be used to identify student misconceptions (Prasetya et al., 2024).

CONCLUSION

In understanding the concept of temperature and heat, eleventh-grade students in Science-Three at Senior High School 8 Malang are still in the moderate category. The study results stated that many students misunderstand the concept of heat capacity and heat equilibrium. The first mistake is in understanding the factors that affect heat capacity. Students are influenced by the mathematical equation $C = \frac{Q}{\Delta T}$ and ultimately think that changes in heat and temperature affect heat capacity. The second mistake is in understanding the concept of heat equilibrium among three objects with the same mass placed in a location with the same temperature. They associate it with the type of material used affecting the temperature of the object. They assume that objects made of conductive materials will have a higher temperature because they absorb heat faster. Therefore, further research recommendations include conduct in-depth interviews with research subjects to determine the extent of their understanding of the material on temperature and heat, as well as identifying any difficulties they may still experience. In-depth interviews were used to gain first-hand insights and experiences from participants.

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REFERENCES

Apriyanti, M., S, H. T. M., & H, M. M. S. (2024). Analisis Miskonsepsi Peserta Didik Menggunakan Three-Tier Test Materi Suhu dan Kalor di SMPN 01 Boyan Tanjung. *Jurnal Dunia Pendidikan*, *5*(1), 305–325.

Azizah, Z., Taqwa, M. R. A., & Assalam, I. T. (2020). Analisis Pemahaman Konsep Fisika Peserta Didik Menggunakan Instrumen Berbantukan Quizizz. *EduSains: Jurnal Pendidikan Sains & Matematika*, *8*(2), 1–11.

Febrianti, J., Akhsan, H., & Muslim, M. (2019). Analisis Miskonsepsi Suhu Dan Kalor Pada Siswa Sma Negeri 3 Tanjung Raja. *Jurnal Inovasi Dan Pembelajaran Fisika*, *6*(1), 90–102. https://doi.org/10.36706/jipf.v6i1.7819

Franklin, B. J. (1992). The development, validation, and application of a two-tier diagnostic instrument to detect misconceptions in the areas of force, heat, light and electricity.Thesis,. *Louisiana State University and Agricultural & Mechanical College*, *April*, 1–347.

Hara, A. K., Astiti, K. A., & Lantik, V. (2023). *Analisis Penguasaan Konsep Fisika pada Materi Suhu dan Kalor Pasca Pembelajaran Online di Kelas XI SMA Negeri 12 Kota Kupang*. *2016*, 118–126.

Hidayat, M. Y., Rikha, S., & Maulida, H. (2022). Penerapan Model Pembelajaran Problem Based Learning (PBL) Untuk Meningkatkan Pemahaman Konsep Application of The Problem Based Learning (PBI) Model To Improve Concept Understanding. *Jurnal Pendidikan Fisika*, *2*(1), 25–26.

Intisavira, T., Sari Mustika, I., & Karim, S. (2023). Profil Pemahaman Konsep Suhu dan Kalor Pada Siswa Sekolah Menengah Atas di Indonesia. *Prosiding Seminar Nasiola Fisika*, *2*(1), 509–514.

Istiqomah, P., Werdhiana, I. K., & Wahyono, U. (2017). Pengaruh Penggunaan Media Video Terhadap Peningkatan Pemahaman Konsep Suhu dan Kalor Pada Siswa Kelas X Man 1 Palu. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, *5*(3), 28. https://doi.org/10.22487/j25805924.2017.v5.i3.8868

Jannah, R., & Haryadi, R. (2020). Pembelajaran Daring Fisika Siswa Sekolah Menengah Atas (SMA). *Edumaspul: Jurnal Pendidikan*, *4*(2), 355–363. https://doi.org/10.33487/edumaspul.v4i2.842

Kamcharean, C., & Wattanakasiwich, P. (2016). Development and implication of a two-tier thermodynamic diagnostic test to survey students' understanding in thermal physics. *International Journal of Innovation in Science and Mathematics Education*, *24*(2), 14–36.

Listyaningrum, T. A., & Widodo. (2024). Meta Analisis Pengaruh Pembelajaran Berbasis Inkuiri Terbimbing dalam Meningkatkan Pemahaman Konsep Fisika. *Jurnal Genesis Indonesia*, *3*(02), 69–79. https://doi.org/10.56741/jgi.v3i02.549

Mustofa, Z. (2021). Pemahaman Siswa Tentang Aplikasi Konsep Suhu Dan Kalor Yang Berkaitan Dengan Komputer. *Jurnal Pendidikan Fisika Undiksha*, *11*(1), 56. https://doi.org/10.23887/jjpf.v11i1.24501

Nafi'ah, Z., Mustikasari, V. R., & Pratiwi, N. (2019). Pengembangan instrumen tes two-tier multiple choice untuk mengukur kemampuan berpikir tingkat tinggi peserta didik SMP pada materi suhu dan kalor. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *3*(2), 115. https://doi.org/10.31331/jipva.v3i2.777

Ni'mah, S. M., Kusairi, S., & Supriana, E. (2019). Profil Miskonsepsi Siswa SMA pada Materi Pembelajaran Suhu dan Kalor. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *4*(5), 586. https://doi.org/10.17977/jptpp.v4i5.12415

Prahestiningtyas, T., & Sulisworo, D. (2022). Pembelajaran Fisika secara Online dengan Aplikasi Seesaw Berdasarkan Scientific Based Learning untuk Peningkatan Kemampuan Berpikir Ilmiah. *Jurnal Penelitian Pembelajaran Fisika*, *13*(1), 81–94. https://doi.org/10.26877/jp2f.v13i1.11108

Prasetya, M., Ramadhan, F., & Alatas, F. (2024). Studi Literatur Terkait Miskonsepsi Siswa SMA Pada Materi Kalor : Implikasi Untuk Pengajaran Efektif. *Seminar Nasional FITK UIN Jakarta*, *1*(1), 160–169.

Pratiwi, N. K. R. (2022). Pengembangan Bahan Ajar IPA Berbasis Multirepresentasi terhadap Pemahamn Konsep Siswa SMP. *Jurnal Pendidikan Mipa*, *12*(2), 359–366. https://doi.org/10.37630/jpm.v12i2.614

Priyadi, R., Suryanti, K., & Varela, L. (2019). Profil Model Pemahaman Peserta Didik pada Topik Suhu dan Kalor: Studi Lintas Pendidikan. *Jurnal Penelitian Pembelajaran Fisika*, *10*(1), 51–56. https://doi.org/10.26877/jp2f.v10i1.3461

Risqa, M., Saehana, S., & Darmadi, I. W. (2021). Pemahaman Konsep Siswa Kelas XI IPA SMA/MA Pada Pokok Bahasan Suhu Dan Kalor Concept Understanding of 11 th Graders of Natural Science Class of High School on Temperature and Heat. *Jurnal Pendidikan Fisika Tadulako Online*, *9*(2), 50–54. http://jurnal.fkip.untad.ac.id/index.php/jpft

Rochaenah, S., & Linuwih, S. (2024). Perbandingan Hasil Kemampuan Literasi Sains Peserta Didik Sekolah Menengah Atas (SMA) dan Sekolah Menengah Kejuruan (SMK) pada Materi Suhu dan Kalor. *Unnes Physics Education Journal*, *6*(1), 1–8.

Said, M. A., & Ishaq. (2024). Pengukuran Tingkat Pemahaman Konsep Fisika pada Materi Suhu dan Kalor. *Jurnal Riset Dan Evaluasi Pendidikan*, *1*(3), 126–132.

Sari, W. P., Suyanto, E., & Suana, W. (2017). Analisis Pemahaman Konsep Vektor pada Siswa Sekolah Menengah Atas. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *6*(2), 159–168. https://doi.org/10.24042/jipfalbiruni.v6i2.1743

Silaban, S. S., & Utari, S. (2015). Analisis didaktik berdasarkan profil penguasaan konsep siswa pada materi suhu dan kalor. *Prosiding Simposium Nasional Inovasi Dan Pembelajaran Sains*, *8*(Snips), 521–524.

Sofianto, E. W. N., & Irawati, R. K. (2020). Upaya Meremediasi Konsep Fisika Pada Materi Suhu Dan Kalor. *Southeast Asian Journal of Islamic Education*, *2*(2), 109–124.

Suhaila, A., Sani, R. A., & Azhar, Z. (2024). Analisis Tingkat Miskonsepsi Siswa Man Binjai Pada Materi Suhu Dan Kalor Menggunakan Three-Tier Multiple Choice Diagnostik Test. *Karst: Jurnal Pendidikan Fisika Dan Terapannya*, *7*(1), 26–33. https://doi.org/10.46918/karst.v7i1.2184

Syahratinnur, Zohdi, A., & Kafrawi, M. (2023). Analisis Tingkat Pemahaman Dan Miskosepsi Fisika Siswa Pada Materi Suhu Dan Kalor Menggunakan Five Tier Diagnostic Test Di SMAN 1 Brang Rea. *CAHAYA: Journal of Research on Science Education*, *1*(1), 1–1330. https://doi.org/10.4324/9780203824696

Taqwa, M. R. A., Priyadi, R., & Rivaldo, L. (2019). Pemahaman Konsep Suhu Dan Kalor Mahasiswa Calon Guru. *Jurnal Pendidikan Fisika*, *7*(1), 56. https://doi.org/10.24127/jpf.v7i1.1547

Widia Linta Nurjanah, Ika Mustika Sari, & Duden Saepuzaman. (2024). Analisis Pemahaman Konsep Peserta Didik Pada Topik Perambatan Kalor Menggunakan Rasch Model. *Didaktika: Jurnal Kependidikan*, *13*(2), 1361–1374. https://doi.org/10.58230/27454312.442

Wulandari, T. A., Prihandono, T., & Maryani. (2018). Analisis Miskonsepsi Siswa pada Materi Suhu dan Kalor di Kelas XI SMA Jember. *FKIP E-PROCEEDING*, *3*(1), 135–139.

Yuliana, I., Artawan, P., & Heny, A. P. (2023). Profil Miskonsepsi Siswa Pada Materi Suhu Dan Kalor. *NUSRA: Jurnal Penelitian Dan Ilmu Pendidikan*, *4*(4), 1161–1166. https://doi.org/10.55681/nusra.v4i4.1763