

Analysis of Understanding And Consistency of Physics Concepts on the Subject of Temperature and Heat in High School Students

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Abstract

The purpose of this research is to analyze the understanding and consistency of physics concepts of high school students on temperature and heat material. This research uses descriptive quantitative research. The population and sample in this study used 12th-grade high school students in Malang in the even semester of the 2023/2024 school year with 33 students. Then the data collection technique here uses a multi-tiered E-diagnostic test. The multi-tier test consists of five levels of instruments with multiple choice questions to determine understanding and see the consistency of student concepts. The number of multi-tier tests used was 15 items on temperature and heat material. The results of the analysis show that students' understanding is in the low category while concept consistency produces a logit person reliability value in the statistical table of 0.03 based on Winstep analysis. It can be understood that both students' understanding and concept consistency are in the very low category of temperature and heat.

Keywords: Conceptual Understanding, Conceptual Consistency, Temperature, And Heat

1. Introduction

Quality education is education that not only prepares individuals for a particular job or position but also to overcome the problems that students face in everyday life. By the curriculum, Hedge stated that one of the main objectives of learning physics is to help students achieve a deep understanding of physics concepts and principles so that they can apply them in solving problems [1]. The aim of learning in physics is to increase students' mastery of knowledge of concepts, facts, and principles, as well as develop students' skills [2]. However, several factors cause students to lack understanding of physics concepts, including 2 factors, namely; (1) students incorrectly respond to the meaning (interpret) of events or symptoms/events of concepts when related to everyday life, (2) the teacher's learning is less focused so that students can misinterpret concepts in everyday life [3,4]. This can cause students to have difficulty implementing physics concepts in different events or situations, so this is also related to students' consistency in understanding physics concepts. Students often lack consistency when completing or answering questions presented in different forms [2]. One of the physics materials where misconceptions or conceptual errors often occur is the material Temperature and Heat [2,4].

Temperature & heat material discusses changes in objects that result in changes in heat energy in objects. The sub-materials of temperature and heat include temperature, heat, heat changing the state of matter, heat transfer, and expansion. These concepts are things that students need to master both physically and mathematically [2]. However, according to the 2019 Puspendik data from the Ministry of Education and Culture regarding student learning outcomes, especially in temperature and heat material, it shows that only around 33-35% of students answered questions correctly. Previous research has also shown that it was found that several students experienced difficulties with temperature and heat material at both high school and college levels [5]. That 301 prospective teachers from various universities in Turkey experienced misconceptions about several physics materials, including temperature and heat. So it can be concluded that there are still many students and prospective teachers who still have difficulty understanding the concepts of temperature and heat[6].

Generally, research that examines the understanding of the concept of temperature and heat uses multi-tier instruments, for example in previous research conducted explained that a three-tier diagnostic test instrument was developed on the topic of temperature and heat in handling Student misconceptions have met the characteristics of a diagnostic test [7]. The research results (Rahayu, et al. 2018) explain that through the three-tier diagnostic instrument, many students still have misconceptions about the material because many students do not give the correct answers at each stage of solving the questions. The use of the Four Tier Digital test instrument showed that overall student misconceptions were 11.08%, 45.69% understood the concept, 33.54% partially understood, and 8.54% did not understand the concept at all [8]. Research conducted by (Syahratinur, et al. 2023) showed the results that analysis of student understanding of concepts and misconceptions using the five-tier diagnostic test instrument obtained a full level of student understanding of 38.93%, a level of misconception of 38.93%, partial understanding of 13.33% and no understanding. concept altogether of 8.80%. As well as research in the context of consistency of students' concepts also uses a multi-tier test instrument in the form of a Three Tier test which shows the results of the level of student learning achievement after applying the Learning Cycle 7E model in the medium category (0.69). The level of scientific consistency is in the medium category (0, 59) [9]. Context Consistency of concepts was also researched by (Windiani, 2016) using the Three-Tier test instrument showing the results that the application of the DSLM learning model can reduce the quantity of students' misconceptions and can play a role in the consistency of students' conceptions of temperature and heat material. However, some use the Quizziz-assisted test on temperature and heat material which shows the results that students understanding the concepts in temperature and heat material are in the medium category (48%) because there are still some students who experience errors in understanding the concept [11].

Based on the researcher's review of previous research, the use of test instruments for understanding concepts is still limited to the use of multi-tier instruments at the Three-tier and four-tier levels in identifying misconceptions and there is only 1 researcher who uses Five-tier test instruments to measure concept understanding. students on temperature and heat material but do not make a connection in measuring the consistency of the concept. Test instruments that measure concept consistency have so far only used three-tier test instruments. So based on this background, researchers are interested in conducting this research to analyze students' conceptual understanding and increase conceptual consistency by using

an instrument that is slightly different from previous studies, namely an instrument in the form of a Five-Tier Diagnostic test on Temperature and Heat material.

2. Research Methods

The research method used in this research is descriptive. The sample for this research used one class of 12th-grade high school students in Malang in the even semester of the 2023/2024 academic year. The data collection technique in this research used a multi-tiered form of E-diagnostic test. The multi-tier test consists of five levels of instruments with multiple choice questions to determine understanding and see the consistency of students' concepts. The number of multi-tier tests used was 15 questions on temperature and heat with the following indicators.

Table 2.1 Question indicators

No	Indicator	Cognate Level		Question	Number of Questions
		C3	C4		
1	Explain draft heat Students can explain that heat conduction occurs only if two objects have different temperatures.	✓		1	1
2	Confirm draft temperature Students can conceptualize that the temperature of an object does not depend on the size of the object, ice cubes do not always have a temperature of 0 °C Student can analyze temperature minimum Which can achieved objects in nature, namely 0 Kelvin.	✓		2	2
			✓	11	
3	Analyze incident equilibrium thermal on application Black Principles Students can relate the density and volume of objects which are inversely proportional to changes in temperature of the object and proportional robust absorbed / expelled by objects Student can determine temperature mixture between two final voluminous 1:2 with temperature Which different with using Black's principle theory, not calculating temperature the mix with add up temperature two final is then division is two two. Student can conceptualize that water Also can temperature 0 oC, Because balanced with temperature ice Which has stop melt.	✓		3	3
		✓		12	
		✓		15	
4	Explain the effect of heat on changes in the temperature of objects Students can analyze temperature something room with given case about heat transfer to objects in the room.		✓	4	1
5	Determine size object Because influence change object temperature (expansion): Students can explain the reasons why tapping is one way to open jam bottles.	✓		5	1
6	Analyzing the effect of heat on changes in the state of objects: Students can analyze fill from bubble moment boiling water, that is water vapor.		✓	6	1
7	Find factors Which can influence heat transfer (air pressure, heat capacity, specific heat, mass): Student can analyze influence heat type to easy or the difficulty of changing an object's temperature. Student can analyze difference point boiling water in mainland rail and lowlands.		✓	7	2
			✓	13	
8	Apply draft displacement heat with method conduction in everyday life: Students can determine the amount of energy received by a steel wire due to the conduction process.	✓		8	1
9	Apply draft displacement heat in a way convection in daily life: Students can apply the concept of heat transfer by convection when mixing low temperature water and high temperature water Student can determine energy Which accepted object from process convection And connection energy Which comparable with changes.	✓		9	2
		✓		14	
10	Apply draft displacement heat with method radiation in daily life: Students can determine the amount of energy received by a black body and the relationship between the energy received/released in the radiation process is proportional to difference from rank four each temperature beginning of time.	✓		10	1

The data collection technique in this research consists of 3 stages, namely, the preparation stage, the implementation stage, and the final stage. The preparation stage consists of several steps carried out by the researcher, including the following: (1) searching for literature related to the research title, (2) determining the research location, (3) determining the research subject, and (4) searching for and compiling the instruments used in research. Next, the implementation stage is filled with giving tests to respondents as a data collection process. The final stage is processing, analyzing data, and drawing conclusions in the research report. The data collection technique was carried out face-to-face and distributed to class 12th-grade high school students with a test duration of 90 minutes.

To find out how well students understand each concept, each student's answer is given a score of 1 for the correct answer and a score of 0 for the wrong answer. Then, respondents were grouped based on each concept, students' scores were calculated, percentages were made, and then the average score for each

concept was calculated. These findings are used to assess students' understanding of the concepts of temperature and heat by making a classification using Table 2.2

Table 2.2 Classification of Concept Understanding

Average skor(%)	Classification of Understanding
81,00 - 100,00	Very good
61,00 - 80,00	Good
41,00 - 60,00	Enough
21,00 - 40,00	Not Enough
0,00 - 20,00	Very Less

(Arikunto,2009)

To determine consistency, test results that produce scores of 1 and 0 (dichotomous data) are analyzed using the Rasch model using Winistep. This model is included in the item response theory. According to the Rasch model, students with high abilities should have a greater chance of correctly answering questions with a higher level of difficulty than other students. The Rasch model method not only considers items but also aspects of the response and correlation. The logit person measure, item measure, person reliability, item reliability, and Cronbach's alpha values will be given by the results of the Winstep statistical analysis. The person measure shows the respondent's ability to answer the question, and the item measure value states the level of difficulty of the question. Person reliability and item reliability show the consistency of respondents. The percentage of correct consistency of respondents' answers for each item was also calculated.

3. Result and Discussion

Result

Data on students' concept understanding is obtained from the results of the five-tier diagnostic test given to students. The following are the results of the recapitulation of students' concept understanding data in solving temperature and heat problems shown in Table 3.1.

Table 3.1 Recapitulation of Concept Understanding Results

Average score (%)	Student Count	Classification of Concept Understanding
41,00 - 60,00	2	Quite
21,00 - 40,00	15	Less
0,00 - 20,00	13	Very poor

Table 3.1 shows the level of students' concept understanding of the concept of Temperature and Heat as a whole. Based on Table 1, only 2 students scored 41.00-60.00, 15 students scored 21.00-40.00, and 13 students scored 00.00-20.00. According to the classification of concept understanding, it shows that the level of student understanding is in the moderately-very poor range with the highest percentage at the poor level. So it can be concluded, that the understanding of the concept of temperature and heat is very poor.

Reliability is the level of consistency of a test instrument. A steady test can provide data that is in accordance with reality, then the test is declared good. The results of data analysis using the Alpha Cronbach formula show that the diagnostic test used in this study is declared reliable with a reliability value of 0.985. This means that the diagnostic test used has a level of persistence in revealing the misconceptions experienced by students about the material Temperature and Heat. Then the student consistency data is seen based on the test results, the average student who answers consistently is only

5.3%. This value is classified as very low because basically, students' understanding is also weak in every concept of temperature and heat.

The above results reflect that in general, students still have weaknesses in achieving good consistency in scientific aspects. In other words, students' low ability causes them not to have enough strength to consistently give the correct answer in every equivalent physics question. The high level of inconsistency indicates that students have difficulty in seeing the relationship between related answer options within the same concept. In addition, based on the Winstep analysis, it was found that the logit person reliability value in the summary statistics table was only 0.03. According to the Rasch model, this value reflects that the consistency of students' answers is still relatively low.

Discussion

Understanding physics concepts reflects individual efforts in dealing with various problems related to physics. This ability is the main goal that must be well mastered by students during the learning process. Concept consistency refers to the ability to maintain an understanding of a physics concept and apply it in solving various problems tested through tests. Conceptual understanding involves aspects such as association, comparison, assimilation, and reorganization of new knowledge, as well as the ability to transfer it to solve problems and apply it in different contexts. In the context of this study, researchers used the Five-tier diagnostic test to evaluate the extent of students' understanding and consistency of physics materials, especially related to temperature and heat.

The Five-tier Diagnostic test refers to an assessment method designed to measure understanding and consistency of concepts. Five levels or stages of questions are structured to identify the extent to which students can apply physics knowledge in a real context. By measuring consistency in concept application, this test helps identify the extent to which students can apply physics knowledge consistently. Based on the data analysis that has been done, it can be seen that the level of understanding and consistency of students is still relatively low. The low category can be caused by several factors, one of the factors that make the level of understanding and consistency of students low is that the data collection of this study was carried out on 12th-grade high school students while temperature and heat material taken by students in 11th-grade high school students even semester so that the majority of 12th-grade high school students experience problems in remembering the temperature and heat material that has previously been taken.

Then, the low understanding of concepts in students in 12th-grade high school students can also be caused by basic conceptual errors obtained in junior high school. Another factor that plays a role is the possibility of inadequate concept construction, with students receiving a number of Physics lessons that focus more on mathematical aspects and less on understanding concepts. As a result, students are more likely to memorize formulas and problem-solving algorithms rather than trying to build a deep conceptual understanding [12]. If the results of this research are compared with previous findings, it can be concluded that in general students face difficulties in understanding the concepts of temperature and heat. However, some findings suggest that changing the structure of topic content or learning methods can somewhat overcome this problem [13].

Understanding concepts has a close relationship with students' consistency in responding and solving problems. The results of the five-tier diagnostic test and analysis using Winstep show that in general, students have a low level of consistency both in each sub-concept and overall regarding temperature and heat. Sometimes, students may use the correct concept, but they do not always reapply it consistently when the context changes, even though the test only involves basic concepts and the context is relatively similar. The differences in different responses from students in situations that should be similar indicate that students' conceptual understanding has not reached an optimal level of consistency.

The above results reflect that overall, students did not show sufficient consistency in the scientific aspect. In other words, the low ability of students caused them to be less able to consistently provide the correct answer for each question that corresponds to Physics concepts. The high level of inconsistency indicates that students have difficulty in identifying answer options related to the same concept. This result is in line with Sriyansyah et al. (2015) who argued that inconsistency causes poor conceptual understanding both in the representation and scientific aspects. This proves that there is a correlation between students' understanding and consistency. Where if the understanding of student concepts increases then the consistency of students will also increase and vice versa.

4. Conclusion

Based on the data obtained, the student's understanding of the concept of temperature and heat is included in the low category while the consistency of the concepts results in a logit person reliability value in the statistical table of 0.03 based on Winstep analysis. It can be understood that the conceptual consistency of the student is in the very low category. Therefore, overall students of class 12th grade high school students in Malang have a low understanding and consistency of the physical concepts of matter Temperature, and Heat.

5. Suggestion

Based on the results of this research, the author suggests that five-tier diagnostic questions can be used to help teachers find out the misconceptions experienced by students in studying the concepts of temperature and heat which will later need to be remedied to improve students' concepts. So with this, students are expected to have a correct understanding of concepts and be able to support 21st-century skills.

References

1. Sutopo, Ida BRJ, Wartono 'Efektivitas Program Resitasi Berbasis Komputer Untuk Meningkatkan Penguasaan Konsep Mahasiswa Tentang Gaya Dan Gerak', *Jurnal Inovasi Dan Pembelajaran Fisika*, 2355 – 7109, pp. 27-35, 2019.
2. Syahratinur, Zohdi A, Kafrawi MNG, "Analisis Tingkat Pemahaman Dan Miskonsepsi Fisika Siswa Pada Materi Suhu dan Kalor Menggunakan Five Their Diagnosis Test di SMAN 1 Brang Rea", *Handbook of Research on Science Education*, vol. 1, no. 1, pp. 1–1330, 2023.
3. Mentari L, Nyoman S, Wayan S, "Analisis Miskonsepsi Siswa SMA pada Pembelajaran Kimia untuk Materi Larutan Penyangga", *E-Journal Kimia Visvitalis Universitas Pendidikan Ganesha Jurusan Pendidikan Kimia*, vol. 2, no. 1, pp. 2014.

4. Rahayu P, Prastowo SHB, Harijanto A, “Identifikasi Pemahaman Konsep Fisika Pokok Bahasan Suhu dan Kalor Melalui Three Tier Test Pada Siswa SMA Kelas XI”. *Seminar Nasional Pendidikan Fisika* vol. 3, no. 2, pp. 89-93,2019.
5. Taqwa MRA, Priyadi R, Rivaldo L, “Pemahaman konsep suhu dan kalor mahasiswa calon guru”, *Jurnal Pendidikan Fisika*, <https://ojs.fkip.ummetro.ac.id/index.php/fisika/article/view/1547>, 2019.
6. Tunç T, Çam HK, Dökme İ. “A Study on Misconceptions of Senior Class Students in Some Physics Topics and the Effect of the Technique Used in Misconception Studies”, *Journal of Turkish Science Education*, vol. 9, no. 3, pp. 137-153, 2012.
7. Sutiana, “No Pengembangan Tes Diagnostik Three Tier Test pada Materi Suhu dan Kalor untuk SM”, <https://dx.doi.org/10.26418/jppk.v7i7.26596> , 2018.
8. Septiyani E, “Identifikasi Miskonsepsi Siswa Menggunakan Tes Diagnostik Four Tier Digital Test (4TDT) Berbasis Website pada Konsep Suhu dan Kalor” pp. 1–225, 2019.
9. Arifah N, Padri IM, Feranie S, “Penerapan Model Learning Cycle 7E Untuk Meningkatkan Konsistensi Ilmiah dan Prestasi Belajar Siswa Pada Materi Suhu dan Kalor”, *Prosiding Simposium Nasional Dan Pembelajaran Sains 2015 (SNIPS 2015)*, pp. 457–460, 2015.
10. Windiani D, “Pengaruh Penerapan Dual-Situated Learning Model (Dslm) Dalam Pembelajaran Fisika Terhadap Penurunan Kuantitas Siswa Yang Miskonsepsi Dan Konsistensi Konsepsi Siswa Pada Materi Suhu Dan Kalor”, *View metadata, citation and similar papers at core.ac.uk*, vol. 3, 274–282. <https://core.ac.uk/download/pdf/144126713.pdf> , 2016.
11. Azizah Z, Taqwa MRA, Assalam IT, “Analisis Pemahaman Konsep Fisika Peserta Didik Menggunakan Instrumen Berbantuan Quizizz”, *Edu Sains Jurnal Pendidikan Sains & Matematika*, vol. 8, no. 2, pp. 1–11,2020.
12. Sriyansyah SP, Suhandi A, Saepuzaman D, “Analisis konsistensi representasi dan konsistensi ilmiah mahasiswa pada konsep gaya menggunakan tes R-FCI”, *Jurnal Pendidikan IPA Indonesia*, vol.4 , no.1, pp.75-82, 2015.
13. Spatz V, Hopf M, Wilhelm T, Waltner C, Wiesner H, “Introduction to Newtonian Mechanics via Two-Dimensional Dynamics-The Effects of a Newly Developed Content Structure on German Middle School Students”, *European Journal of Science and Mathematics Education*, vol. 8, no. 2, pp. 76- 91, 2020.

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