

Analysis of High Order Thinking Skills of High School Students in Solving Heat and Thermodynamics Problems

Sasti Handayani Wakhidyah*, Imam Mudakir, & Sri Wahyuni

Master of Science Education Study Program, University of Jember, Indonesia

*Corresponding Author: sastihandayaniw14@gmail.com

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Abstract - Higher order thinking skills are skills that 21st century students should have in order to compete globally. Higher-order thinking skills involve complex thinking processes, including analysing, evaluating and creating. This study aims to analyse students' higher order thinking skills in solving heat and thermodynamics problems. The samples used in this study were grade 12 students in the 2024/2025 academic year, as many as 64 students. Data collection was carried out through the results of high thinking ability tests on heat and thermodynamics material with Bloom's taxonomy domain levels C4, C5, and C6. The method used is quantitative method with purposive sampling technique. The results of this study, students have the ability to analyse (C4) by 61.34%, the ability to evaluate (C5) by 26%, and the ability to create (C6) by 12.66%. The conclusion of this study is that students are in the good category in the analysing aspect, the less category in the evaluating aspect and the very less category in the creating aspect. This means that students can complete the completion stage but are less able to compile information so that they are unable to produce perfect answers.

Keywords: HOTS; Heat; Thermodynamics

INTRODUCTION

The era of revolution 5.0 requires students to master 21st century skills which consist of three main abilities, namely the ability to think, act, and live (Marwan et al., 2020). The ability to think is the basis of problem solving. Thinking is a mental activity that a person experiences when they are faced with a problem or situation that must be solved. From this, it can show that to be able to find out problems or solve problems, he must carry out an activity called thinking (Komariyah, 2018). The more advanced the era of revolution, the tighter the competition so that the quality of education must also be improved (Desiriah & Woro, 2021). Education is a strategic means and vehicle in the development of human resources (Wakhidyah, 2023). Therefore, education must receive serious attention and handling. Education provides students with the opportunity, hope, and knowledge to live a better life. Education can be a force for change to make a condition

better (Gaol et al., 2022). Education in the 21st century also demands various skills that need to be mastered by students, so education is expected to prepare students to have these skills to become successful individuals in life (Yurika et al, 2023). According to the OECD (Organisation for Economic Cooperation and Development), Indonesian students score below other OECD countries in science. Therefore, a standardised curriculum that meets the needs of the 21st century is needed.

Curriculum governs the education of a nation. The education system in Indonesia is governed by an independent curriculum as the standard of education. Education cannot be implemented, and educational goals cannot be realised if the curriculum does not exist. The curriculum is seen as a plan that is prepared in the teaching and learning process under the guidance and responsibility of educational institutions and their staff. The independent curriculum is designed as a curriculum that gives students

the freedom to organise their own learning and adjust to the abilities of the students. The independent curriculum is also known as the prototype curriculum. This means that it is flexible. Learning methods in the independent curriculum are more interactive and collaborative (Lestari et al., 2023). The teacher is a facilitator in guiding students so that their burns and interests can develop (Nadhiroh & Ashori, 2023). In the teaching and learning process, teachers have the task of encouraging, guiding and facilitating learning for students to achieve goals (Faizin et al., 2022). Learning is a process of interaction between students and teachers and learning resources in an environment. The teacher acts as a provider of information and students as recipients of information (Khotimah, 2017). The existence of an independent curriculum is expected to improve the quality of students in various fields, not only academic but also non-academic (Vhalery et al, 2022). In the academic field, students are required to have high-level thinking skills, so that they have critical thinking and reasoning power (Suryaman, 2020).

High-level thinking ability (HOTS) is a learner's skill in understanding knowledge that not only remembers but also teaches in contacting information that is owned at a higher level of thinking so that it is able to analyse, evaluate, and create an idea (Desiriah & Setyarsih, 2021). Brookhart in (Suhady et al, 2020) stated that the purpose of implementing Higher Order Thinking Skills (HOTS) is so that students are accustomed to providing arguments correctly and making conclusions correctly. The importance of Higher Order Thinking Skills (HOTS) is in line with the curriculum objectives contained in the basic framework and structure of the SMA/MA curriculum (Fanani, 2018).

Survey results from Trends in International Math and Science conducted by Global Institute, high-level reasoning questions can only be done by 5% of Indonesian students (Asri, 2017). Judging from other studies, the higher-order thinking skills of high school students in Jember still vary greatly. Agustina et al (2019) stated that the ability to think at a high level in MAN students in Jember was in the medium category in 2 MANs and one was found in the low category. A'yunina et al (2019) stated that the ability to think at a high level in Muhammadiyah 3 Jember high school students had a percentage at the stage of analysing with a high category, at the stage of evaluating with a high category, and at the stage of creating with a medium category. The data shows that students' higher-order thinking skills vary at each stage. One way to see the process, progress, and improvement of student learning outcomes is the need for an assessment.

In this research, the instrument used as an assessment is the HOTS-based heat and thermodynamics test. The Higher Order Thinking Skills (HOTS)-based heat and thermodynamics test is used to determine how high students' higher order thinking skills are. The heat and thermodynamics material was chosen because the material has concepts that occur in everyday life (Winarti & Budiarti, 2020).

RESEARCH METHODS

The research location was held at Pancasila Ambulu High School, Jember Regency. The time of this research was October. The population in this study were 12th grade students in the 2023/2024 academic year with a total of 64 12th grade students. The research method used was descriptive with a quantitative approach (Ariansyah et al., 2019). Quantitative research is a form of scientific research that

examines one problem from a phenomenon and looks at possible links or relationships between variables in the specified problem (Irvan et al., 2023). The sampling technique used was purposive sampling (Masrurah et al, 2020).

The instrument used was a set of 8 physics essay questions related to heat and thermodynamics based on Higher Order Thinking Skills (HOTS), consisting of 2 questions with level C4, 4 questions with level C5, and 2 questions with level C6. In this study, a research procedure was made to facilitate the completion of the research. The research procedure consisted of three stages: (1) Preparation Stage, which includes collecting data from literature sources related to heat and thermodynamics, and designing research instruments; (2) Implementation Stage, which includes testing the validity of research instruments by validators until they are considered valid, collecting data through student answer sheets from the results of filling out questions; (3) Final Stage, which includes assessing and scoring the results of student answers based on the assessment rubric, analysing the assessment data, and drawing conclusions based on data analysis. To see the category of higher order thinking ability

owned by students using criteria according to the following table

Tabel 1. HOTS Category based on International Center for the Assessment of Higher Order Thinking Skills (Sugiyono, 2019)

Score	Category
1 – 100	Very Good
61 – 80	Good
41 – 60	Moderate
21 – 40	Poor
0 – 20	Very Poor

The analysis of higher order thinking skills obtained from the test results will be categorised based on the International Center for the Assessment of Higher Order Thinking Skills.

RESULTS AND DISCUSSION

Results

The achievement of students' higher order thinking skills at Pancasila Ambulu High School, Jember Regency, based on the scores obtained from the heat and thermodynamics tests using Higher Order Thinking Skills (HOTS), can be observed in Figure 1.

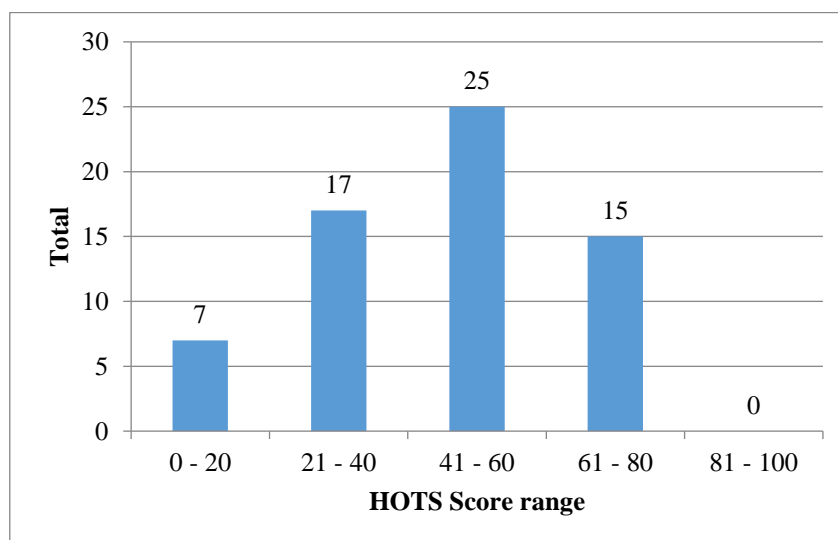


Figure 1. The range of scores obtained by students

The number of students occupying each category in higher order thinking can be seen in Table 2.

Table 2. Test Analysis Results

Category	Student	Percentage
Very Good	0	0%
Good	15	23,44%
Moderate	25	39,06%
Poor	17	26,56%
Very Poor	7	10,94%

In addition, this study also analysed students' higher-order thinking skills based on indicators of higher-order thinking in the cognitive domain which includes three aspects, namely aspects of analysing, aspects of evaluating, and aspects of creating, the results of which can be seen in Table 3.

Table 3. Student Ability Results Based on HOTS Indicators

Indicators	Percentage
Analyse (C4)	61,34%
Evaluate (C5)	26%
Create (C6)	12,66%

Discussion

Based on the *Higher Order Thinking Skills (HOTS)*-based temperature and heat test questions tested on 64 12th grade students of Pancasila Ambulu High School, there were no students who had excellent high-level thinking skills, 15 students or equivalent to 23.44% of the total students had good high-level thinking skills, 25 students or equivalent to 39.06% of the total students had sufficient high-level thinking skills, 17 students or equivalent to 26.56% of the total students had poor high-level thinking skills, and 7 students or equivalent to 10.94% of the total students had very poor high-level thinking skills. The data obtained is different from the data from the results of research conducted by Ramadhan et al (2018) which states that for high-level thinking skills in the very good category has

a percentage of 0%, for high-level thinking skills in the good category has a percentage of 4%, for high-level thinking skills in the sufficient category has a percentage of 11%, for high-level thinking skills in the less category has a percentage of 45%, and for high-level thinking skills in the very poor category has a percentage of 40%.

In research conducted by Marsiana et al., (2021) stated that the ability to think at a high level of students in class XI IPA MAN 2 Soppeng. Follow-up form of evaluation of learning outcomes of students in class XI IPA MAN 2 Soppeng. Students' higher-level thinking skills are still relatively low. Where in this case it is shown based on the results of the high-level thinking ability test in class XI IPA that 95% are remedial with 39 students. While the other 5% of students have passed or met the standard that scores more than the minimum completeness criteria. The form of enrichment and remedial follow-up given to students varies depending on the number of indicators that have not been completed by students. Two learners were given follow-up enrichment, and 39 other learners were given.

Meanwhile, research conducted by Nizam et al., (2023) stated that the students' high-level thinking skills in solving temperature and heat problems were low with an average of 34.08. The profile of students' high thinking ability at the level of analysing (C4), evaluating (C5), creating (C6) is 33.6%, 34.0%, 34.4% of the ideal score, respectively. Data collection was carried out by giving a questionnaire of learning independence and higher order thinking skills test to 126 students of class XI MIA at SMA Negeri 1 Sungai Raya.

Many factors are the cause of the inequality of the results obtained, for example, student background, student ability, school facilities, different living environments and many more. The

researcher also analysed students' abilities based on indicators of higher order thinking skills, including aspects of analysing (C4) all students have the ability with a percentage of 61.34%, aspects of evaluating (C5) all students have the ability with a percentage of 26%, and aspects of creating (C6) all students have the ability with a percentage of 12.66%. In the HOTS category according to the *International Center for The Assessment Of Higher Order Thinking Skills*, the percentage of 61.34% in the analysing aspect is in the good category, the percentage of 26% in the evaluating aspect is in the poor category, and the percentage of 12.66% in the creating aspect is in the very poor category. The analysing aspect includes students' ability to rebuild information into smaller parts to find out patterns and relationships. In the aspect of evaluating includes the ability of students to provide an assessment of an idea. The creating aspect includes students' ability to make general conclusions from an idea or perspective on something. The data shows that students' ability to rebuild information into smaller parts to find out patterns and relationships, students have good abilities. Students' ability to provide an assessment of an idea, students have a lack of ability, while students' ability to make general conclusions from an idea or perspective on something, students have a very lacking ability. Follow-up in the form of enrichment and remediation varies depending on the results of the tests that have been carried out and students' errors in answering questions on certain indicators.

CONCLUSION

Based on the Higher Order Thinking Skills (HOTS) based heat and thermodynamics test questions tested on 64 12th grade students of Pancasila Ambulu High School in the indicators of higher order thinking according to the International

Center For The Assessment of Higher Order Thinking Skills, in the aspect of analysing (C4) students have the ability with a percentage of 61.34% which occupies the sufficient category, in the aspect of evaluating (C5) all students have the ability with a percentage of 26% which occupies the sufficient category, and in the aspect of creating (C6) all students have the ability with a percentage of 12.66% which occupies the less category. Broadly speaking, in the aspect of analysing (C4) students have a good ability in describing information including known and asked in the problem correctly and completely and are able to formulate the steps to solve the problem correctly. In the aspect of evaluating (C5) students have less ability in completing the steps of solving the problem correctly and giving the right conclusion but there are still many students who do not write units. In the aspect of creating (C6) students have a very poor ability in designing and integrating information obtained from the analysis and evaluation process so that the answers written are less precise.

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