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Analysis of Students' Ability in Solving Physics Problems on the Concept of Thermodynamics for Class XI SMAN 2 Binongko

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ABSTRAK. The majority of physics learning in high school is still considered difficult to understand and has an impact on low ability to solve the problems given. This research aims to (1) determine students' knowledge abilities in solving physics problems on thermodynamic concepts. (2) Knowing students' understanding abilities in solving physics problems on thermodynamic concepts. (3) Knowing students' application abilities in solving physics problems on thermodynamic concepts. (4) a description of students' analytical abilities in solving physics problems on thermodynamic concepts. This research method uses a quantitative descriptive research design. The subjects in this research were class XI students at SMAN 2 Binongko. The data collection technique used essay test questions which were then given to class XI students. The research results show that (1) Students' ability to solve physics questions at the knowledge level (C1) is categorized as high with a percentage of 44%. (2) Students' ability to solve physics questions at the understanding level (C2) is categorized as moderate with a percentage of 36%. (3) Students' ability to solve physics questions at the applied level (C3) is categorized as very low with a percentage of 64%. (4) Students' ability to solve physics questions at the analysis level (C4) is categorized as very low with a percentage of 75%.

1. Introduction

The current learning process is more focused on students with the implementation of the 2013 curriculum (K-13), so that learning is more student-centered rather than teacher-centered. The 2013 curriculum (K-13) provides opportunities for students to develop independently, so that students have the skills to live as individuals who are faithful, productive, creative, innovative and affective. Teachers always require students to learn, but do not teach how students should learn and solve problems in the learning process (Wahyuni, 2022).

Physics is one of the educational modules distributed in schools and has a fundamental role in making the direction of national education a success. Physics itself is a part of natural science that is studied using sensory equipment (Halmuniati et al., 2022). Physics learning is always divided into two things, namely process and product. In the Minister of Education regulation no. 23 of 2006, regarding graduation competency standards, it is explained that the science and technology study group has the aim of developing students' logic, thinking and analytical skills (Rahayu et al., 2018).

Physics at the advanced level (SMA) is still considered complicated for some students. Apart from that, physics lessons are thought to be saturated because they can only be done by competent students and teachers provide modules only in formulaic form so that students have difficulty grasping the knowledge of physics. Therefore, teachers need to design learning that is simple and fun so that it can be accepted by students with different skills and so that it can change students' perceptions about physics (Ady, 2022).

Based on the results of interviews conducted by researchers with the physics subject teacher at SMA Negeri 2 Binongko, Mrs. Suhuria, the students' ability to complete physics lesson questions on previous material seen from the students' test results was still relatively low even though the teacher always provided example questions and exercises during the lesson. physics. The educator explained that the average learning outcome score for physics students in class XI Science at SMA Negeri 2 Binongko was an average score of 58.4. With this, the researcher wants to explore or deepen the learning outcomes of students in class XI Thermodynamics lessons on cognitive aspects.

Students' success in physics lessons depends on their intelligence in understanding concepts, definitions, laws and theories. Teaching and learning activities in class do not always run easily. Every teacher often encounters students who have difficulty in studying things such as understanding theory, mathematical calculations and problem solving (Handayani et al., 2018).

Problem solving skills are the way individuals utilize previous knowledge and skills to synthesize and apply them to new contexts (Fatimah et al., 2019). This capability requires a high level of utilization of existing knowledge. Every problem solved requires high-level thinking.

Based on the explanation of problem solving abilities, an evaluation needs to be carried out to determine student learning gains. Evaluation is used to measure whether the process of improving students' mindsets has functioned well and whether the programs and activities carried out have achieved educational goals. One technique for assessing cognitive learning outcomes is an oral test in the form of questions (Fitri et al., 2022). Assessment of learning outcomes is based on measuring student performance, namely demonstrated skills. A very important assessment instrument is to be able to recognize students' thinking skills regarding learning activities that have been carried out previously. This is demonstrated by students' skills in completing assessment questions. The assessment tool used must be in accordance with the current curriculum, namely the 2013 curriculum, so that the assessment tool has an impact on the assessment. In line with research conducted by (Kurniawan et al., 2023) that measuring problem solving abilities using essays will make it easier for teachers to see the quality of their students' work.

In this study, researchers wanted to find out about students' cognitive abilities by developing a test instrument for physics essay questions on the concept of thermodynamics as a tool for evaluating the learning outcomes of students at SMA Negeri 2 Binongko. Researchers compiled questions based on Bloom's taxonomy which has different levels of questions. The implementation of this assessment tool is to determine students'

skills in answering physics questions in the cognitive aspect and achieving learning objectives, as well as as teacher evaluation material for models, the methods that teachers apply can increase students' interest and learning outcomes in thermodynamic concepts. Based on the background explanation above, research to analyze students' abilities in solving physics questions on class XI thermodynamics concepts at SMAN 2 Binongko needs to be carried out.

2. Method

This research is quantitative descriptive research. This research was conducted from January 16 to February 22, 2023, even semester of the 2022/2023 academic year. This research was conducted at SMA Negeri 2 Binongko, which is located in Popalia, Togo Binongko, Wakatobi Regency, Southeast Sulawesi 93794. The subjects of this research were class XI Science at SMA Negeri 2 Binongko, totaling 36 students, 12 men and 24 women. The research procedure consists of 3 stages, namely the preparation stage, implementation stage and data collection stage. The instrument used is an essay test with 20 questions at the cognitive level of remembering (C1), understanding (C2), applying (C3) and analyzing (C4) whose validity and reliability values have been tested. (Anderson & Krathwohl, 2010).

3. Results and Discussion

3.1 Result

Remembering (CI)

The test results for the ability to solve questions at the remembering level (C1) are shown in the following table;

Table 1. Descriptive Analysis Results of Student Learning Outcome Scores

Statistical Parameters	Mark
Maximum Value	100
Minimum Value	60
Average	87.11
Standard Deviation	13.04
Variance	170.16

Based on table 1 above, students can get a maximum score of 100 and a minimum score of 60. All students have an average of 87.11 with a variance and standard deviation of 170.16 and 13.04 respectively.

Based on the data on the ability to solve questions at the cognitive remembering level (C1) and the descriptive analysis above, it is shown in the following table:

Table 2. Frequency Distribution of remembering (C1)

Interval Class	Frequency	Percentage
60-66	4	11%
67-73	0	0%
74-80	13	36%
81-87	0	0%
88-94	1	3%
95-100	18	50%

Amount	36	100%

Table 2 shows that the number of students in the 60-66 value interval is 4 students (11%), there are no students in the 67-73 value interval (0%), the number of students in the 74-80 value interval is 13 students (36%), there are no students in the 81-87 value interval (0%), the number of students in the 88-94 value interval is 1 student (3%), and in the 95-100 interval is 18 students (50%).

Based on table 2, the grouping of categories contained in the tendency distribution is divided into several group is very high, high, medium, low and very low. This can be reviewed above the following table.

Table 3. Distribution of Remembering Categories (C1)

Interval Class	Fi	(%)	Category
X<70	8	22	Very Low
70≤75	0	0	Low
75≤80	0	0	Currently
80≤90	16	44	Tall
90≤100	12	33	Very high

From table 3, it shows that the very high group consists of 12 students. at 33%, the high group consists of 16 students (44%), very low group consisting of 8 students (22%). Therefore, it can be concluded that the highest student's ability to know is at 44%. The results of student abilities show that students' ability to solve questions at the level of knowing (C1) on the concept of thermodynamics for class XI of SMAN 2 Binongko is categorized as high.

Understanding (C2)

The results of students' ability to solve problems on thermodynamic concepts are presented in the table below;

Table 4 Results of Descriptive Analysis of Student Learning Outcome Scores

Statistical Parameters	Mark
Maximum Value	100
Minimum Value	50
Average	77.36
Standard Deviation	17.75
Variance	314.98

Based on table 4, the highest student learning score is 100 and the lowest score is 50. The average learning score of all students is 77.36. The standard deviation and variance are 17.75 and 314.98.

Based on table 4, it can be seen that the ability to solve questions at the cognitive level of understanding (C2) and descriptive analysis can be shown in the following frequency distribution table.

Table 5 Frequency Distribution of Understanding Ability (C2)

Interval Class	Frequency	Percentage
50-58	8	22.22%
59-67	0	0%

68-76	13	36%
77-85	3	8%
86-94	3	8%
95-104	9	25%
Amount	36	100%

Table 5 shows that the number of students in the 50-58 value interval is 8 (22.22%), there are no students in the 59-67 value interval (0%), the 68-76 value interval is 13 (36%), the 77-85 value interval is 3 (8%), the 86-94 value interval is 3 students (8%), and the 95-104 value interval is 9 students (25%).

Based on table 5, the grouping of categories contained in the tendency distribution is divided into several groups , namely very high, high, medium, low and very low. This condition is shown in the following table.

Table 6. Distribution of Understanding Ability Categories (C2)

Interval Class	Fi	(%)	Category
X<70	8	22	Very Low
70≤75	0	0	Low
75≤80	13	36	Currently
80≤90	3	8	Tall
90≤100	12	33	Very high

From table 6, it shows that the very high group consists of 12 students. with a percentage of 33%, 3 students are high (8%), while there were 13 students (36%) and very low as many as 12 students (33%). Based on these results, it can be concluded that the highest student understanding ability is at 36%. The results of students' abilities show that students' ability to complete questions at the cognitive understanding level (C2) on the thermodynamics concept for class XI of SMAN 2 Binongko is categorized as moderate.

Applying (C3)

The results of students' ability to solve problems using thermodynamic concepts at the applying level (C3) can be seen in the table below:

Table 7. Descriptive Analysis Results of Student Learning Outcome Scores

Statistical Parameters	Mark
Maximum Value	100
Minimum Value	28.5
Average	62.96
Standard Deviation	21.14
Variance	442.88

Table 7 above shows that the highest student learning score is 100 and the lowest score is 28.5. The average learning score of all students is 62.9. The standard deviation and variance are 21.04 and 442.88.

Based on data on cognitive problem solving ability (C3) and descriptive analysis, it is shown in the following frequency distribution table.

Table 8. Frequency Distribution of Ability to Apply (C3)

Interval Class	Frequency	Percentage
28-39	4	11%
40-51	9	25%
52-63	8	22%
64-75	3	8%
76-87	2	6%
88-100	10	28%
Amount	36	100%

Table 8 shows that the number of students in the 28-39 value interval is 4 students (11%), the number of students in the 40-51 value interval is 9 students (25%), the number of students in the 52-63 value interval is 8 students (22%), students above the 64-75 value interval are equal to 3 students (8%), in the 76-87 value interval are equal to 2 students (6%), and in the 88-100 value interval are 10 students (28%).

Based on table 8, the grouping of categories contained in the distribution of tendencies is divided into several categories , namely very high, high, medium, low and very low. This condition is shown in the following table.

Table 9 Distribution of Application Ability Categories (C3)

Interval Class	Fi	(%)	Category
X<70	23	64%	Very Low
70≤75	1	3%	Low
75≤80	0	0%	Currently
80≤90	9	25%	Tall
90≤100	3	8%	Very high

students in the very high category. with a percentage of 8%, 9 students are high (25%) , low by 1 student (3%) and very low number of 23 students (64%) . Based on these results, it can be concluded that students' ability to solve questions at the application level (C3) on thermodynamic concepts in class XI of SMAN 2 Binongko is classified as very low.

Analyzing (C4)

The results of students' ability to solve problems on thermodynamic concepts at the analytical cognitive level (C4) are shown in the following table.

Table 10. Descriptive Analysis Results of Student Learning Outcome Scores

Statistical Parameters	Mark
Maximum Value	90
Minimum Value	5
Average	43.47
Standard Deviation	27.67
Variance	765.56

Table 10 above shows that the highest student learning score is 60 and the lowest score is 0. The average learning outcomes of all students are 29.58 . The standard deviation and variance are 29.58 and 386.25.

Based on data on cognitive analysis problem solving ability (C4) and descriptive analysis, this can be shown in the following frequency distribution table:

Table 11. Frequency Distribution of Analytical Ability (C4)

Interval Class	Frequency	Percentage
5-19	5	14%
20-34	13	36%
35-49	2	6%
50-64	7	19%
65-79	3	8%
80-95	6	17%
Amount	36	100%

Table 11 shows that the total number of students above the value interval 5-19 is 5 people (14%), students above the value interval 20-34 is 13 people (36%), in the value interval 35-49 is 2 people (6%), students in the value interval 50-64 is 7 people (19%), students in the value interval 65-79 is 3 people (8%), and in the value interval 80-95 is 6 students (17%).

Based on table 11, the grouping of categories contained in the distribution of tendencies is divided into several categories, namely very high, high, medium, low and very low. This can be shown in the table below .

Table 12. Distribution of Analytical Ability Categories (C4)

Interval Class	Fi	(%)	Category
X<70	27	75%	Very Low
70≤75	0	0%	Low
75≤80	3	8%	Currently
80≤90	3	8%	Tall
90≤100	3	8%	Very high

From table 12 shows that the very high category is 3 students or 8%, high is 3 students (8%), medium is 3 students (8%), very low is 27 students (75%) and there is no low group. Therefore, it can be concluded that the ability of students to solve analysis level questions (C4) on the thermodynamics concept of class XI SMAN 2 Binongko is categorized as very low.

3.2 Discussion
Remembering (C1)

At the first cognitive level, namely knowing, students work on a description of 2 question numbers in class XI IPA thermodynamics material, with the aim of finding out students' abilities in solving problems or student learning outcomes.

The results of the research showed that the students' ability to solve questions at the cognitive level of remebering (C1) obtained the highest score of 100 and the lowest score of 60 with an average score of 87.11 with a total of 36 students. Students in the highest percentage group were 44% with a high categorization, 33% in the very high category and 22% in the very low category, with no medium and low categories. In the matter of the cognitive level of knowing, some students are able to remember or re-memorize the material that has been studied and some students have not been able to completely remember the material studied so that the

students' grades or learning outcomes are still in the very low category, namely 60, even though this level is the lowest level, it is a prerequisite. for the next level. At this level students do not experience difficulty solving questions because the questions are not calculation-based.

Based on the explanation above, it can be concluded that the ability to solve physics questions for class XI IPA at SMAN 2 Binongko is categorized as high. This research is relevant to research (Novisya, 2017) with the results of the research, the ability to know was 40.68%, the ability to understand was 37.83%, the ability to apply was 27.11% and the ability to analyze was 21.81%. So it can be concluded that students answer more questions with the ability to know and students do not experience difficulties in solving because the questions are not based on mathematical calculations, they only require basic knowledge of theory in thermodynamics. This is in accordance with the hypothesis (Hardianti, 2018) which explains that each student has different learning capacities and understanding of physics. This situation is also caused by the varying skills development capacity of each student. Cognitive processes or mental work are described in this way. How someone collects data, presents and transforms that data into knowledge, stores that knowledge in memory, and then retrieves it is an example of a mental process or idea. Apart from that, it is said that learning outcomes are the result of cognitive processes. The psychological aspect is that students' readiness in the learning process has a significant impact on learning products, because learning products tend to increase when students are ready to learn (Johari, 2018).

Understanding (C2)

At the second cognitive level, namely understanding (C2), students are given questions consisting of 2 description test questions with questions number 3 and 4 in class XI IPA thermodynamics material which aims to determine students' understanding abilities in solving problems or student learning outcomes.

The results of the research showed that the students' ability to solve questions at the cognitive level of understanding (C2) obtained the highest score of 100 and the lowest score of 50 with an average score of 77.36 with a total of 36 students. Students in the highest percentage group were 36% with medium categorization, 33% in the very high category, 8% in the high category, 22% in the very low category, and no low category. In questions at the cognitive level of understanding, some students are able to understand the material that has been studied and some students are not able to understand the material as a whole, so that the students' grades or learning outcomes are still in the very low category, namely 50. At this level of questions students do not experience difficulty solving questions because the questions not based on calculations or analysis, students only understand the questions without needing to take a physics approach in solving the questions.

Based on the explanation above, it can be concluded that the ability to work on physics questions for class XI IPA at SMAN 2 Binongko is categorized as medium with the highest percentage being 36%. This research is relevant to research by (Yunus, 2021) with research results showing that knowledge skills (C1) were 100%, understanding skills (C2) 92.4%, application skills (C3) 86.86%, and analysis skills (C4) 58.58%. So it can be concluded that students respond more to knowledge questions and students have difficulty responding to analysis questions, which are based on this research. This is in accordance with the idea that students need to pay serious attention in order to achieve high learning outcomes. Focusing attention on the material being studied and students' learning goals is called interest. Increased learning outcomes are a consequence of the desire to excel in learning (Hafizah, 2020).

Applying (C3)

At the third cognitive level, namely applying (C3) using a number of questions from 2 description test numbers, with questions number 5 and 6 in class XI IPA thermodynamics material with the aim of finding out students' application skills in solving problems or student learning outcomes.

The research results showed that the students' ability to work on applied cognitive level questions (C3) obtained the highest score of 100 and the lowest score of 28.5 with an average score of 62.96 with a total of 36 students. Students in the highest percentage group are 64% with a very low category, 8% in a very high category,

3% in a low category, 25% in a high category, and no medium category. On the question of the applied cognitive level, some students were able to apply the material they had studied and some students were not able to apply the material as a whole, so that the students' grades or learning outcomes were still in the very low category, namely 28.5. At this question level, students have difficulty solving questions because the questions are calculation-based, students' errors in answering questions are in the use of formulas and partly in mathematical procedures or final solutions.

Based on the explanation above, it can be concluded that the ability to work on physics questions for class XI IPA at SMAN 2 Binongko is categorized as very low with the highest percentage being 67%. This research is relevant to research by (Miftana, 2015) with research results showing that remembering power (C1) was 78.12%, understanding (C2) 67.03%, application (C3) 53.31% and analysis (C4) 21.42%. So it can be concluded that students experience difficulties in working on application and analysis questions. This is in accordance with the assumption that problem solving skills are the same as the way a person synthesizes and applies his knowledge and understanding to actual and varied circumstances (Wardani et al., 2021).

Analyzing (C4)

At the fourth cognitive level, namely analysis (C4) with question number 1, description test number, with question number 7 in class XI IPA thermodynamics material with the aim of knowing students' analytical abilities in solving problems or student learning outcomes.

The research findings show that students' skills in solving questions at the cognitive level of analysis (C4) obtained the highest score of 90 and the lowest score of 5, the average was 43.47 with a total of 36 students. All students are in the highest percentage group, namely 75% with the categorization of very low, very high 8%, high 8%, medium 8%, and no low group. On questions at the cognitive level of analysis, all students were unable to analyze the questions correctly. At this level of questions, students must be able to remember, understand and apply to be able to solve questions at the analysis level, so that students can solve questions accurately. Students really have difficulty working on questions at this level of analysis because the questions are based on calculations or analysis, students' mistakes in answering questions are in the description or understanding of the content of the questions, such as the known quantities, what is asked in the question, applying the equation to the question and the final solution.

Based on the explanation above, it can be concluded that the ability to solve physics questions for class XI IPA at SMAN 2 Binongko is categorized as very low with the highest percentage being 75%. This research correlates with research by (Muslimin et al., 2018) with research results showing that the level of remembering (C1) is 96.15%, understanding (C2) 83.85%, applying (C3) 34.42%, and analyzing (C4) is 34.62%, with the conclusion that students It is very easy to solve questions at the very first level, namely the knowledge level, and has difficulty solving questions at the analytical level. This is in line with the explanation by (Juhanda, 2016). The average percentage of cognitive level questions from C4 (analysis), C5 (evaluating) and C6 (creating) in the Higher Order Thinking Skills category is very low. These skills are very important for students to have. At this level of questions, students are expected to think complexly. Skills for complex thinking are skills needed in critical thinking.

4. Conclusion

There are 3 types of student expertise in working on thermodynamics material questions at the cognitive description level (C1), namely very high, high, and very low. There were 12 students or equal to 33% with the very high type, 16 students or 44% with the high type, and 8 students with the very low type. At SMAN 2 Binongko, students' skills in responding to level of Remembering (C1) questions regarding thermodynamics concepts were categorized as high with a score of 44%.

There are 4 categories of student expertise in solving thermodynamic ideas questions at the cognitive understanding level (C2) which can be divided into very high, high, medium and very low. There are 12 students

or equal to 33% who are in the very high group, 3 students or as much as 8% are in the high group, 13 students or 36% are classified as medium and 8 students (22%) are classified as very low. With a percentage of 36%, the results of class XI students at SMAN 2 Binongko's level of understanding (C2) are classified as moderate.

There are 4 categories of cognitive problem solving ability applying (C3) thermodynamic concepts, namely very high, high, medium and very low. There were 3 students (8%) in the very high category, 9 students (25%) in the high category, 1 student (3%) in the low category, and 23 students (64%) in the very low category. Based on survey findings, the ability of class.

There are 4 categories of skills in working on cognitive analysis questions (C4) on thermodynamic concepts, namely very high, high, medium and very low. There were 3 students (8%) in the very high category, 3 students (8%) in the high category, 3 students (8%) in the medium category, and 27 students (75%) in the very low category. Based on research findings, the ability of class

Acknowledgements

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