The profile of student’s problem solving skill using analytical problem solving test (apst) on the topic of thermodynamics

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Abstract. This study aims to analyze students problem solving skill in solving analytical problem solving test on the topic of thermodynamics. The research approach used is quantitative with descriptive method. The research subjects were 100 students of senior high school in Ngawi. Instrument test research used analytical problem solving test was modified of national examination test. Instrument test in the form of essay test which measure of 4 indicator problem solving skill by G Polya : (1) Understanding the Problem, (2) Devising plan, (3) Carrying out the plan, (4) Looking Back. The results show that percentage achievement of understanding the problem (58.40%), Devising plan (70.92%), Carrying out the plan (65.52%), looking back (42.88%). It shows that the student problem solving skill of senior high school in Ngawi is still moderate category so it’s necessary to do improvement effort.

1. Introduction
Physics is a subject that can improve student skills that are useful for solving problems in everyday life [1]. One of the concepts of physics that must be mastered by students is thermodynamics [2]. Thermodynamics is very closely related to daily life, so Thermodynamics is a subject related to energy and is one of the ingredients needed to understand natural phenomena [3]. Thermodynamics has an important role in human life. Thermodynamics is an important topic that must be studied in physics because of its many applications in science and technology [4]. Barak stated that there are four groups of abilities that need to be mastered by each student, namely how to think, how to work, tools to work and live in the world [5]. The ability to think is a group of thinking skills such as problem solving skills [6]. Problem solving skills are in the 21st century that make students solve problems in everyday life [7]. Problem solving skills can enhance students' higher-order thinking skills such as logical thinking, critical thinking, creative thinking, and reasoning thinking [8]. Problem solving skills are emphasized in the learning process at school, especially in teaching and learning. Problem solving skills are not only needed in mathematics but in all subjects related to problem solving in everyday life such as physics [9]. The subject of physics is a conditional subject, meaning that every new concept always requires the preconditions of understanding and prior knowledge so that the concepts of one another relate to each other [10]. This causes the subject of physics to demand a relatively high intellectual level such as the ability to solve problems [10]. This is also supported by Mundilarto that the ability that is really needed when understanding physics is the ability to calculate, manipulate and observe and the ability to solve problems critically [11].
Assessments conducted on an international scale, there are two types of problems that have been raised for the assessment of problem solving skills namely Analytical Problem Solving (APS) and Interactive Problem Solving (IPS) and Collaborative Problem Solving (CoIPS) [12]. Analytical problem solving has characteristic problems that can be solved analytically, because all the information needed to find a solution is given at the beginning of the problem [13]. Interactive problem solving has characteristic problems that can be solved by adjusting the initial plan and knowledge at various time points because there is feedback after every interaction with the problem [13]. Collaborative problem solving has the characteristics of analytical problem solving and interactive problem solving. Analytical problem solving, interactive problem solving and collaborative problem solving are valid approaches for assessing students' problem solving skills. In this study, assessing students' problem solving skills using analytical problem solving tests. This is due to analytical problem solving tests seem to be more strongly associated with intelligence on school achievement than interactive problem solving [14,15].

Based on these descriptions it can be concluded that the analytic problem solving test can measure students' problem solving. Solving student problems is one of the goals of physical learning [17]. Therefore, it is important to analyze students' problem solving skills. This is because the results of the analysis can be used as a reference or evaluation basis for teachers to determine appropriate learning to improve the quality of problem solving skills for students [18].

2. Methods
This research method uses survey methods. Survey research has several steps including: 1) Research Objectives, 2) Concepts, 3) Questionnaires / tests, 4) Population, 5) Sampling, 6) Data Collection, 7) Data Processing, 8) Interpretation [19]. This research uses descriptive quantitative research. Quantitative research is obtained by the results of test scores with student answers [20]. Problem solving skills in each Indicator are determined through the results of tests that have been analyzed. Indicators of problem solving skills adopted from G Polya: (1) Understanding Problems, (2) Designing plans, (3) Implementing plans, (4) Looking Back [21]. Research subjects were 100 senior high school students in Ngawi. In this study the data collected was obtained by using an analytical problem solving test which was changed from the national examination test in the form of a written description test. The essay test consists of 5 questions about the concept of thermodynamics which includes 4 indicators of problem solving skills. The rubric of problem solving skills assessment was adopted by Hidayat with the score used was 0 to 4 [22]. The overall results are recorded according to each indicator. Based on the percentage of achievement the results meet the requirements. Calculation results of problem solving skills are calculated using equation 1 to determine the percentage of students' problem solving skills achievement.

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\text{Percentage Achievement(\%)} = \frac{\text{Average score based on each indicator}}{\text{Maximum Score}} \times 100\%
\] (1)

The results of the percentage of achievement of students' problem solving skills on each indicator can be seen in Table 1.

| No | Percentage | Category   |
|----|------------|------------|
| 1  | 81%-100%   | Very good  |
| 2  | 61%-80%    | Good       |
| 3  | 41%-60%    | Moderate   |
| 4  | 21%-40%    | Low        |
| 5  | 0%-20%     | Very Low   |

3. Results and Discussion
Each student has different problem solving skills for each indicator. According to G Polya, to measure the level of students' problem solving skills there are 4 indicators that can be used namely (1)
Understanding the problem, (2) Planning a plan, (3) Implementing a plan, (4) Looking back. Analytic problem solving tests are one of two types of assessment tests that can measure students' problem solving. Students' answers from analytic problem solving tests were analyzed using the rubric of problem solving skills assessment which can be seen in table 2.

Table 2. Assessment Rubric of Problem Solving Skill

| An Indicator of Problem Solving Skill | A Score of Each Indicator |
|--------------------------------------|---------------------------|
|                                      | 4 | 3 | 2 | 1 | 0 |
| Understanding the Problem Identifying the variables which are being asked | All description variables which are being asked is right and complete | One part of the description of the problem is incorrect or incomplete | More than one part of the description is incorrect or contains errors | Almost all description variables are incorrect and contain errors | All description variables which are being asked is incorrect and contains errors |
| Devising Plan Determining the physics concepts to solve a problem | Using the right, complete and appropriate physics concepts | One of the physics concepts that are incomplete or contain errors | More than one physics concept that is incomplete or contains errors | Almost all physics concepts are incomplete and contain errors | The whole physics concept is incomplete and contains errors |
| Carrying Out the Plan Using physics concepts to solve the problem asked | The physics concept & mathematical procedure used is appropriate and complete | Physic concept & mathematical procedure is complete but contains a few errors | One of physic concept and a mathematical procedure is incomplete or contains errors | More than one physics concept & mathematical procedure that is incomplete and contains errors | All of the physics concept and mathematical procedures are incomplete or contain errors |
| Looking Back Rechecking the truth of the answer and concepts | The whole answer to the problem is clear, focused, and logical | The answer is clear and focused but contains one error | More than one answer is unclear, not focused, or inconsistent | Almost all answers are unclear, out of focus, and not consistent | All answers are unclear, out of focus, and not consistent |

Noting the overall value based on each indicator. By using analytic problem solving tests based on the results of students' problem solving skills on the topic of thermodynamics in the form of essays containing 4 indicators of problem solving skills, the results of the percentage of achievement of problem solving skills in each indicator can be seen in Table 3.

Table 3. Category of Problem Solving Skill

| An Indicator of Problem Solving Skill | Percentage | Category |
|--------------------------------------|------------|----------|
| Understanding the Problem            | 58.40%     | Medium   |
| Devising Plan                        | 70.92%     | Good     |
| Carrying Out the Plan                | 65.52%     | Medium   |
| Looking Back                         | 42.88%     | Medium   |

The percentage of problem solving skills in table 3, it can be seen that the percentage of students' problem solving skills achievement in completing analytic problem solving tests for indicators understanding the problem, implementing the plan and looking back occupies in the medium category, only the indicators compiling the plan occupy the good category. Achievement on indicators understanding the problem has a medium category, meaning students are quite able to identify problems in the form of problem sketches and identify problems. The indicators compiling a plan get a good category that is showing that students can determine the equations and concepts of physics in solving a problem. The percentage of achievement of implementing plans in the medium category, means students
are quite capable of using concepts or physics equations to solve problems. The indicator looks back at getting a medium category so that it shows that students have difficulty in checking the correctness of the answers and the suitability of the concept.

Based on the results above, the conclusion is that the average student has problem solving skills in the medium category. To find out more about problem solving skills for each student, it is necessary to analyze the profile of problem solving skills for each student. This is because in each student the problem solving ability differs from one student to another student. This is due to several factors such as students' cognitive abilities. The percentage of problem solving ability categories in each aspect can be seen in Figure 1.

Based on Figure 1, the category of students' problem solving abilities on each indicator varies. The indicator understands the problem, the data shows that most students are in the moderate category, which is 28% and only 10% of students in the excellent category. This shows some students who have difficulty giving a problem description of an analytical problem. This causes several factors such as the difficulty of students in providing symbols and units of each problem presented in the problem.

Indicators of planning plans show that the majority of students are in the medium and good category, which is 33% and only 1% in the very low category. This shows that some students can determine the concepts of physics and mathematics equations to solve analytical problem solving problems. This is due to several factors such as students' lack of understanding of the use of some equations in thermodynamics based on certain conditions. This is due to students not having procedural knowledge that can help students to determine strategies to solve problems.

Indicators of the implementation of the plan show that most students are in the good category, which is 47% and there are no students in the very low category. This shows that most students have been able to solve analytical problem solving questions based on predetermined mathematical concepts and equations. This is due to several factors such as the lack of students' metacognition skills which causes students not to evaluate every step that has been taken.

Looking back at the indicators, it was found that most students were in the low category at 44% and there were only no students in the excellent category. This shows that some students find it difficult to re-check the correctness of the answers and the suitability of the concept in solving analytical problems.

![Figure 1. Percentage Category Student Problem Solving Skill of Each Indicator](image-url)
This is because most students only think of the final answers to problems that make many ways abandoned [24]. Examples of problem solving analytic tests and student answers for each problem solving category can be seen below.

4) A Carnot engine with 60% efficiency is operated between 2 heat reservoirs with a low temperature reservoir of 27 °C. In order for the Carnot engine to use 80% and the low temperature reservoir to be made constant, determine the required temperature rise in the high temperature heat reservoir!

Figure 2. Question of Analytical Problem Solving Test (APST) about Carnot engine

Figure 3. Student answer in very low category of problem solving skill

Figure 4. Student answer in low category of problem solving skill

Figure 5. Student answer in moderate category of problem solving skill

Figure 6. Student answer in a good category of problem solving skill

Figure 2 can be seen about the questions from the analytical problem solving test about the Carnot engine. In Figure 2, a description of the efficiency of a Carnot engine with temperatures in a low reservoir is presented, students are expected to determine an increase in temperature in a high reservoir to increase the efficiency of a Carnot engine. The problem presented can be solved analytically, because all the information needed for the problem [14]. Figure 3 shows students answering in the category of
very low problem solving skills having to answer questions by experiment. Students cannot identify the variable being asked, it makes students answer the question incorrectly. Figure 4 shows the answers of students in the category of problem solving skills that have answered the question incorrectly. In the low category, students can identify the requested variable, but make students solve problems unclearly. Figure 5: Students show answers in the medium category, problem solving of the answers to the questions is correct but incomplete. In the medium category, students can identify the variable being asked and determine the problem, but students use this equation, he uses incomplete answers. Figure 6 answers of students in both categories shows the problem solving skills have answered the correct and complete questions, but have few errors. In either category, students can identify the variable being asked and solve the problem, but students do not have answers and the suitability of the concept, this makes the answers have fewer errors. Student answers in the excellent problem solving skills category have answers to correct and complete questions. In a very good category, students can identify the variable being asked and answer the truth and answer the concept right, it makes the answer clear and consistent [22].

Based on the results, it can be seen that students cannot determine what to do and finish to get solutions to problems. One solution to improve students' problem solving skills through the application of learning models that involve skills in problem solving, contextual assignments, practical processes in problem solving, discussions related to problem solving processes, and teaches how to solve problems before students complete all subject matter.

4. Conclusion
Based on the description of the results and discussion, it can be concluded that the problem solving of students in completing analytic problem solving tests on the topic of thermodynamics is the medium category. The results showed that the percentage of achievement understood the problem (58.40%), planned the plan (70.92%), carried out the plan (65.52%), looked again (42.88%). The results of this study can be used as a basis for choosing learning strategies that are able to train and provide problem solving skills. Using learning models that can train students' high-level thinking skills can improve problem solving skills so that students are reflected through learning activities in the classroom or laboratory.

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