



The Ability of Chemistry Problem Solving of Senior High School Students in Palu Sulawesi Tengah

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The research is purposed to describe the problem-solving ability of the Senior High School XI grader students in Palu city. The measurement of the problem-solving ability could be determined by solving the exercises of Hydrocarbon and Thermochemistry topics using the Polya's sequences; consisting of understanding the problem, devising, doing the plan, and evaluating. The ability of students' problem solving is classified well in every sequence in case of the number of high category students is 60%. The samples are 240 of 507 XI grade students learning chemistry in SMAN 3 and SMA Madani Terpadu in Palu City. The data of problem-solving is determined by providing a test in the form of a validated essay. The result shows the average of XI graders in Palu City only capable of solving the problem without understanding, devising, and evaluating while solving hydrocarbon topics. The ability is not even possessed by students in Thermochemistry. It implies that senior high school students in Palu could not represent the problem in the form of figure, symbol, statement, and mathematics statement or have not been able to devise the problem solving and correlate the obtained result with the related theory or concept. Therefore, the students should be trained to solve the problem in learning by application the problem-solving sequences.

Keywords: Problem-solving, Polya's sequences, hydrocarbon, thermochemistry

Introduction

One way to increase students' understanding and mastery of chemistry is to emphasize the importance of problem-solving abilities. The ability must be trained and equipped for all students, especially when facing complex problems in learning chemistry (Harta, 2017). The ability to solve problems is influenced by students' understanding of material related to problems and thought processes as mental activities carried out by students to find solutions (Ijirana & Supriadi, 2018).

According to Adair (2009), when a person is faced with a problem either alone or in a team, there are three steps in solving the problem, consisting of understanding the problem, leading to problem-solving, evaluating decisions, and implementing them. The important thing that someone needs to do when solving problems is to arrange and organize the knowledge related to the problem to be solved. Knowledge organizing is intended to activate declarative knowledge, while procedural knowledge is a sequencing action consisting of finding and evaluating solutions. If someone has been able to solve a problem, the person can not only solve similar problems but also be expected to solve different problems in daily life (Gagne et al., 1992). Therefore, in problem-solving, there is an

interactive relation between declarative and procedural knowledge. The procedural action is meant to understand the problem, find a solution, and evaluate the result.

Procedural knowledge in relation to problem-solving abilities has been described by Polya (1973), that there are four stages of problem-solving, consisting of 1) understanding the problem, in this activity, students need to identify what is known, available, the number, correlation, and values associated with, and what will be sought. Some suggestions that can help students understand complex problems, consisting of; (a) asking questions about what is known and searched for, (b) explaining the problem in its own words, (c) relating to other similar problems, (d) focusing on important parts of the problem, (e) develop a model, and (f) develop a diagram; 2) devise for completion (division a plan) Students need to identify the operations involved as well as the strategies required to solve a given problem. This is usually done by students in ways such as (a) guessing, (b) developing a model, (c) sketching a diagram, (d) simplifying problems, (e) identifying patterns, (f) developing tables, (g) experimenting and simulating, (h) reverse working, (i) testing all possibilities, (j) identifying sub-objectives, (k) developing analogies, and (l) sorting data/information; 3) carry out the plan of completion (carry out the plan). What is

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implemented obviously depends on what has been planned in advance and also includes the following: (1) interpreting the information provided in mathematical form; and (2) implementing the strategy during the ongoing process and calculation. In general, at this stage, students need to maintain the plan they have chosen. If such a plan cannot be implemented, students can choose another method or plan; 4) evaluating (looking back) the following aspects need to be taken into account when reviewing the previous steps involved in solving the problem, consisting of (a) rechecking all important information that has been identified; (b) checking all the calculations involved; (c) considering whether the solution is logical; (d) looking at other alternative solutions; and (e) re-reading the question and re-asking own self whether the questions have been really answered well.

Problem-solving ability is very important for students. According to Huang & Chen (2020), education should be a focus on improving students' ability to think and to solve problems. It is affected by the problem-solving abilities that are directly related to critical thinking skills and student competency levels. The results also show that students having high problem-solving abilities would have higher competence and better critical thinking skills (Chuang, 2011) and also improve self-management (Chen et al., 2020). Therefore, it is important to measure students' problem-solving abilities to predict critical thinking skills and the achievement of student competencies which are the goals of the 2013 curriculum.

Other studies have also found that problem-solving abilities could be perceived to have an effect on artificial intelligence (AI) (Xu et al., 2020), cognitive style, and sex (Mefoh et al., 2017). The problem-solving ability of students with the dependent field cognitive style is higher than the dependent learning style as well as the male is higher than the female. Based on the research findings, it is very important to conduct research on problem-solving abilities for high school students especially in chemistry, so that the teacher can model their learning based on the level of students' ability in problem-solving. The research objective was to describe the problem-solving abilities of the XI grade students of SMAN in the city of Palu.

Methods

The case study research was conducted at SMAN 3 and SMA Model Terpadu Madani Palu, which was designed in the form of a chimney or inverted triangle (adaptation from Anggito & Setiawan, 2018). Part of the chimney shape, consisting of initial orientation, exploration, testing, and confirmability. The population in this study were all Class XI high school students in Palu City who were actively registered in the 2019/2020 school year. The sample of the study was taken randomly, where the selected schools were SMAN 3 Palu and SMAN Model Terpadu Madani, with total of 240 students.

The test instrument used in this study aims to measure students' problem-solving abilities in Hydrocarbons and Thermochemistry. Measures of problem-solving ability adapted from Polya (1973). The number of problems used is 5 points involving all the concepts in both materials. The test instrument was developed by adapting the XI Class' Chemistry Book of Curriculum 2013 under 2016 revised edition (Sudarmo, 2016), Basic Chemistry (Petrucci, 2011), and Organic Chemistry (Riswiyanto, 2009) and has been theoretically and empirically validated with an average validity value of 0.73.

The data obtained were analyzed descriptively. The level of student problem-solving ability was measured by adopting the method used by Ijirana (2016) by calculating the total score of students' problem-solving stages of each problem item divided by the number of maximum scores. Furthermore, students' abilities are categorized into 5 categories, consisting of; very low, low, moderate, high, and very high. Students are classified as able to solve problems well if at least 60% of students obtain at minimum high category abilities.

Results and Discussion

Problem-solving skills are one of the important competencies that need to be nurtured and developed among high school students (Ninh, 2018). This study aims to describe the problem-solving abilities of high school students and data obtained in this study are the analysis result of the problem-solving abilities of class XI MIA students at SMAN 3 Palu and SMAN Model Terpadu Madani on the topic of Hydrocarbons and Thermochemistry consisting of understanding problems, devising, implementing the completion plan and evaluating. The concepts contained in Hydrocarbons consist of Carbon Atoms Characteristics, Hydrocarbons Nomenclature, Isomers, Reaction Equations, and Addition Reactions. The concepts contained in the topic of Thermochemistry are Calorimeters systems, Environment, Exothermic Reactions, Enthalpy Changes, Bond Energy, and Hess' Law.

The results of the analysis of students' ability to solve problems for each concept in the topic of hydrocarbons are described in Figures 1-5. The data in Figures 1-5 show that, in general, the chemical problem-solving abilities of XI grade students in Palu city on the topic of Hydrocarbons have good abilities at the planning stage and implementing problem-solving plans. The ability could be seen in 4 concepts in the topic of hydrocarbons, consisting of; the concept of hydrocarbons nomenclature, isomers, reaction equations, and addition reactions. The ability to understand and evaluate every time students do problem-solving is low. It is caused by students thinking no need to write down what has been known so that students are more focused on the planning and problem-solving stages.

Specifically, the students' ability to solve hydrocarbon problems based on the problem-

solving stage in Figures 1-5 shows the following: 1) students have not been able to understand the problem well in all concepts in the topic of hydrocarbons because only an average of 36.83% of students has the ability. 2) students have been able to devise problem-solving on the concept of hydrocarbon nomenclature, isomers, combustion reactions, and additive reactions, with an average of 87%, although the ability has not been possessed by students yet in the concept of the carbon atom characteristics. 3) As many as 87% of students have been able to carry out the problem-solving stages well on all the concepts in hydrocarbons. 4) On average, 26% of students have not been able to evaluate the results on the concept of hydrocarbon nomenclatures, isomers, combustion reactions, and additive reactions, but 69% of the ability has been possessed by students in solving the problems of carbon atom characteristics.

The low ability of students to understand the problem and evaluate the results of problem-solving is caused by students not having prior knowledge and not understanding the concepts well, so they are unable to correlate the concept underlying with

their understanding of the problem because understanding conceptual knowledge is a prerequisite for being able to apply procedural knowledge. According to Anderson & Krathwohl (2001), when students solve problems using cognitive processes in the realm of applications, they will require students to understand the problem and its solution procedure to the level of evaluating. Therefore, solving problems requires several categories of cognitive processes, from understanding to the level of creation.

At the review stage, students need more time and higher levels of thinking in problem-solving because students must be able to provide logical evidence to correlate the results obtained with students' understanding of the concept. If students are able to evaluate the results of solving the problem, it means that in addition to solving the problems, they are also able to apply the facts, laws, and principles learned and could think critically (Ijirana, 2016) self-regulating (Chen et al., 2020) Students able to think critically also has the ability to analyze information obtained in daily life.

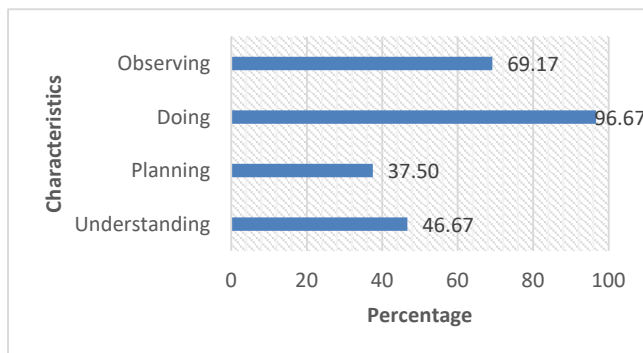


Figure 1. Percentage of students with problem solving ability of carbon atom characteristics concept

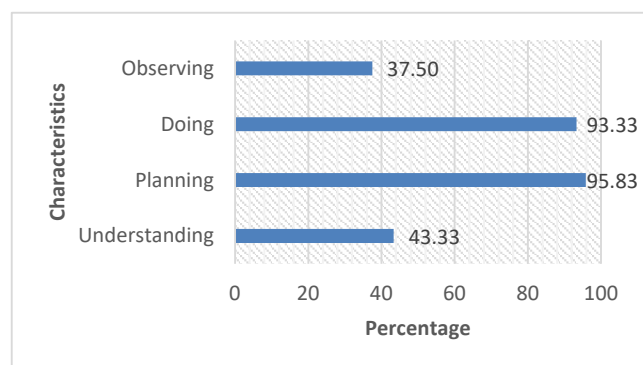


Figure 2. Percentage of students with problem solving ability of hydrocarbons nomenclature concept

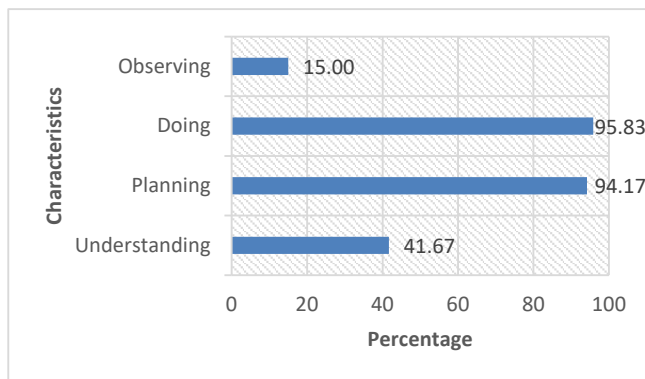


Figure 3. Percentage of students with problem solving ability of isomer concept

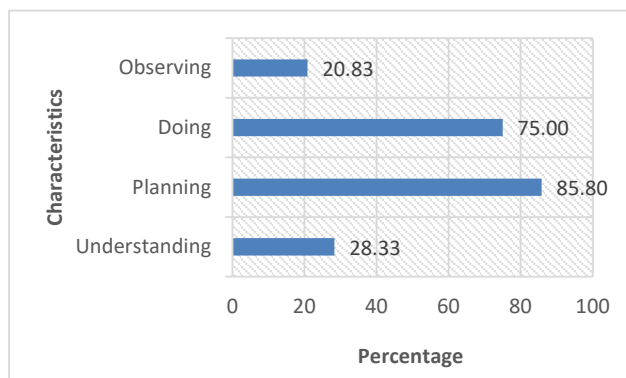


Figure 4. Percentage of students with problem solving ability of combustion reaction

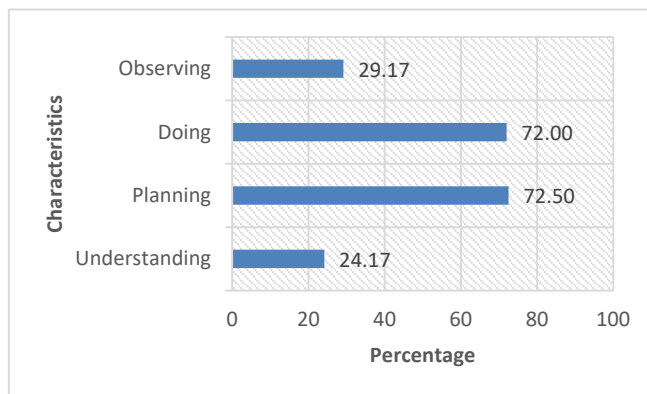


Figure 5. Percentage of students with problem solving ability of addition reaction concept

The analysis result of students' ability to solve problems for each concept in thermochemistry are described in Figures 6-10.

The data in Figures 6-10 show that generally, XI grade students of Senior High School in Palu City have not been able to solve problems well on the topic of Thermochemistry. Good abilities are possessed by students only at the planning stage on the concept of calorimeters, enthalpy changes, and Hess's law. This indicates that students of Senior High School in Palu City are only able to devise problem-solving plans without being able to

understand, to implement plans, and to evaluate the problem-solving.

Specifically, the students' ability to solve thermochemical problems based on the problem-solving sequences in Figures 6-10, shows the following: 1) students have not been able to understand problems well in almost all concepts in thermochemistry except for the calorimeter concept. The ability of students to understand problems in the concept of systems, environment, exothermic reactions, enthalpy changes, bond energies, and Hess's law is only about 56%. 2) students have been able to devise problem-solving

on the concept of calorimeters, enthalpy changes, and bond energy with an average of 83%, while the number of students who have not had the ability yet on the concepts of systems, environment, exothermic reactions, and bond energy is 45%. 3) The students' ability to do the problem solving properly is 76% on the concept of calorimeters, systems, environment, exothermic reactions, and

enthalpy changes and as many as 56% of students are unable to carry out this stage on the concept of bond energy and Hess's law. 4) All students have not been able to evaluate the results of solving problems properly on the topic of thermochemistry. Only 52% of students are able to perform the stage of evaluating the results of problem-solving on all concepts in thermochemistry.

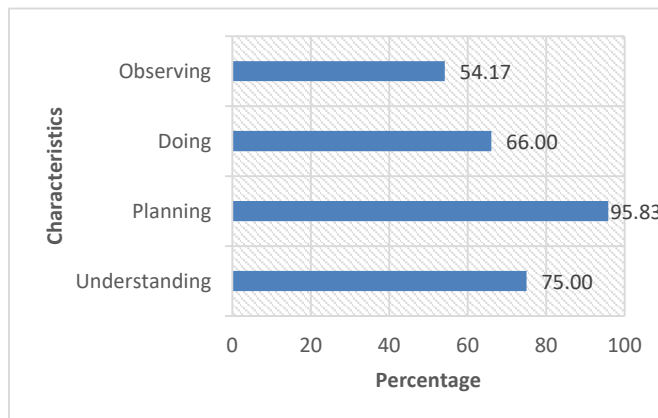


Figure 6. Percentage of students with problem solving ability of calorimeter concept

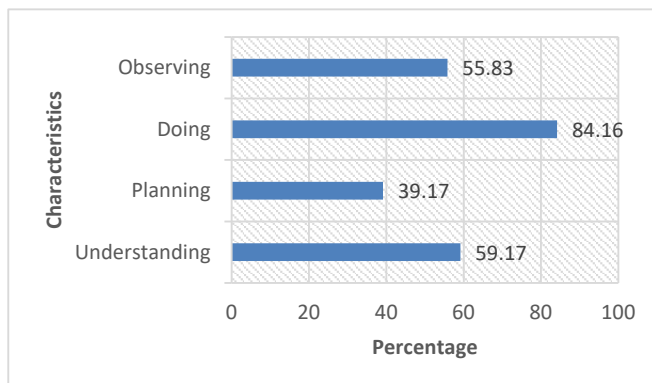


Figure 7. Percentage of students with problem solving ability of system, environment and exothermic reaction concept

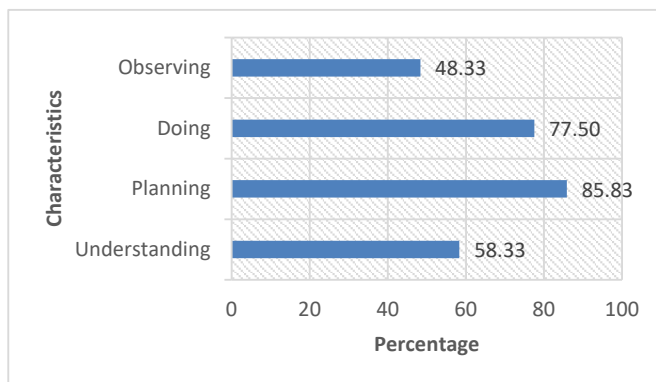


Figure 8. Percentage of students with problem solving ability of enthalpy change concept

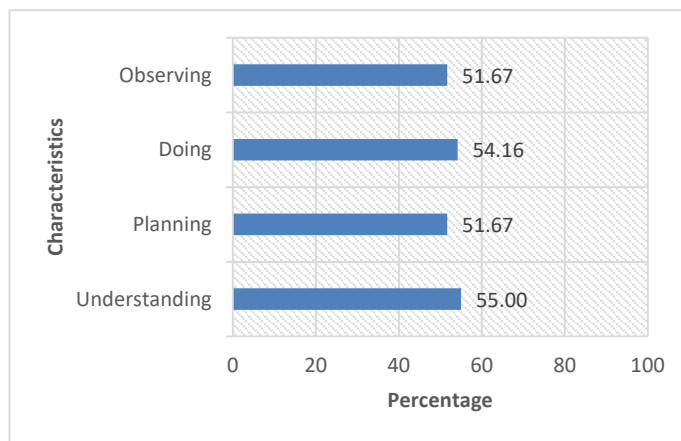


Figure 9. Percentage of students with problem solving ability of bonding energy concept

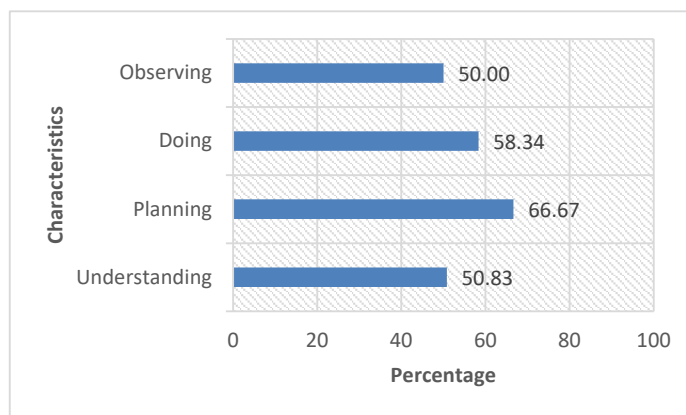


Figure 10. Percentage of students with problem solving ability of Hess' law concept

The low ability of students in understanding, devising, and evaluating the results of the problem-solving shows the difficulty of students to determine the formula to be used to solve a given problem. That the stage of devising a solution has a high level of difficulty, when compared to the other stages. Likewise, with the stage of understanding the problem, this stage is intended to define and understand the elements contained in the subject matter and to be the initial matter in the formulation of a problem-solving capability strategy (Maemanah et al., 2019). Hence, at this stage, students are required to think about what steps should be taken to solve the problem. The inability of students in the problem-solving stages indicates that students solve problems directly into action, not initiated by careful planning (Yanti et al., 2017). Students have not been accustomed in systematical sequence learning (Ijirana & Nadjamuddin, 2019), even though there is an interaction between learning models and problem-solving abilities (Surya & Putri, 2017), such as the findings of Hadi & Radiatul (2014) that the application of problem-solving methods according to Polya can develop problem-solving abilities, namely understanding problems, making problem-solving plans, carrying out plans/calculations, and checking results.

Students' mathematical problem-solving abilities, self-efficacy, and mathematical metacognition can also be significantly improved through guided discovery-based learning (Simamora et al., 2019); problem-based learning (Siagian et al., 2019; Sulistiyanti et al., 2021); and the development of chemical problem-solving abilities can be improved through integrated learning (Volayuth, 2019). Other studies have also found that problem-solving abilities can also increase the level of metacognition and use of good strategies in solving problems in daily life (Siagian et al., 2019), and this is in accordance with the achievement of learning objectives in the 2013 curriculum.

Conclusions

The analysis and assessment of the students' problem-solving abilities in XI grade of Senior High School in Palu City concluded that the problem-solving abilities of students on the topic of hydrocarbons are generally only able to solve problems without being able to understand, devise and evaluate the results of the problem-solving. This shows that students do not understand the concepts of hydrocarbons well. The ability to solve problems on thermochemistry topics is generally still low for all concepts, and students have not been able to

devise and evaluate the results properly. The difference in the ability of these two topics shows that the students' ability to apply concepts in mathematical calculations is still low, and they are not even skilled at interpreting problems by representing images, symbols, and statements into other forms or vice versa.

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