# DESCRIPTION OF STUDENT LEARNING DIFFICULTIES IN THE THERMOCHEMISTRY

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**Abstract:** Thermochemistry is a material high school students study in class XI MIPA in odd semesters. In this material, 83.69% of SMAN 13 Padang class XI MIPA students still need to achieve the minimum completeness criteria set. It indicates that students have learning difficulties. Learning difficulties are failures to attain learning goals characterized by low learning outcomes. This study aims to determine the percentage of students who experience learning difficulties for each indicator on thermochemistry material and determine the factors that cause learning difficulties experienced by students in terms of learning methods. This research is a type of descriptive research. The sample for this research was students in class XI MIPA 6 at SMAN 13 Padang in the 2022/2023 academic year, which consisted of 34 people. The research instrument was a diagnostic test *with four-tier multiple-choice* questionnaires and interviews. The data analysis used is descriptive, namely analyzing and providing an understanding of the data in the form of numbers so that an overview can be given in an orderly, concise, and transparent manner. The results of this study stated that students of SMAN 13 Padang had difficulty learning thermochemistry material in the high category. The highest difficulty level is found in the sixth indicator (determining the ΔH value of the reaction through a calorimeter experiment), which is 90.20%. Meanwhile, the lowest level of learning difficulty for students is found in the first indicator (explaining differences in systems and environments in chemical reactions), which equals 42.16%. Learning difficulties experienced by students are caused by ineffective learning methods, such as not making a study schedule and not carrying it out, not reading and not taking notes, not repeating material, not concentrating, and not doing assignments.

**Keywords:** *Learning Difficulties, Thermochemistry, Diagnostic Tests, Four-Tier.*

## INTRODUCTION

Learning is a business process carried out by someone to get something to form new behavior in a better direction. However, in reality, there are still students who have yet to be able to achieve learning goals or have yet to obtain changes in behavior as expected. It shows that students struggle to achieve learning goals [1].

Learning difficulties are failures in achieving learning goals, characterized by low learning achievement (the value obtained is less than the standard minimum completeness criteria set), so students fail to achieve learning goals [1]. Students' low learning outcomes are caused by certain obstacles, such as internal and external factors [2].

Chemistry is a subject that is considered difficult by students [3]. It is because chemistry consists of abstract concepts and requires mastery of mathematical operations and a strong memory [4]. Therefore, students are required to have the ability to understand concepts and apply understanding of mathematical operations. Understanding the concept is a very important aspect of learning chemistry because by understanding the concept, students can develop their abilities in each subject matter. Based on the results of distributing questionnaires and interviews with chemistry teachers at SMAN 10 Padang, SMAN 5 Padang, and SMAN 13 Padang, it can be seen that thermochemistry material is difficult for students to understand. Of the three schools, SMAN 13 Padang has the highest percentage of students who get daily assessments under the KKM at 83.69%.

Students of class XI MIPA at SMAN 13 Padang have yet to reach the Minimum Completeness Criteria standard set at 80. It indicates that students need help learning thermochemistry material to improve learning outcomes. Students obtained them to be low / below the minimum completeness criteria. However, it still needs to be made clear which indicators these students experience difficulties.

To find out the extent to which students have difficulty understanding the material being taught, it can be determined by giving a diagnostic test. A diagnostic test is one of the tests used to determine students' weaknesses so that appropriate treatment can be carried out [5]. In contrast, the provision of questionnaires and interviews was conducted to determine the factors that cause learning difficulties experienced by students in terms of how to learn.

The way of learning affects the achievement of learning outcomes. Learning outcomes are used as a benchmark in achieving the learning objectives set for students who participate in a learning series [6]. If students have found a way of learning that suits them, then learning activities will be easily carried out by these students so that students can achieve high learning outcomes [7].

Related research that discusses learning difficulties in learning chemistry includes Kadek's research, which states that the learning difficulties experienced by students are caused by a low understanding of concepts in buffer solution material, students' ability to operate mathematics is weak, and negative influence from peers [8]. Maryana's research stated that the cause of students' learning difficulties was due to the non-implementation of effective learning methods [9].

To reveal the learning difficulties experienced by class XI MIPA students at SMAN 13 Padang, it is necessary to research so that appropriate solutions can be found to help students overcome the learning difficulties they experience. Therefore, researchers are interested in researching which indicators students consider difficult and the causes of these difficulties from how students learn thermochemistry material.

**RESEARCH METHODS**

The type of research used is descriptive research. Descriptive research is a form of research that aims to describe existing phenomena [10]. The sample in this study was 34 students in class XI MIPA 6 at SMAN 13 Padang. This research was conducted in the odd semester of the 2022/2023 academic year at SMAN 13 Padang.

In this study, the instrument used was a diagnostic test sheet (four-tier multiple choice), questionnaire sheets, and interview sheets. Previous researchers have made the diagnostic test instrument used and is valid.

Students are considered to understand a concept they are learning if the answers and reasons are correct and their confidence level is high [11]. Students with wrong answers and reasons and a low confidence level are classified as students who need help understanding the concept [12].

The diagnostic test given to students is in the form of four-level or multiple-choice questions, a total of 25 questions representing nine learning indicators, namely the indicators 1) explaining differences in systems and environments in chemical reactions; 2) explaining the difference between exothermic reactions and endothermic reactions; 3) explains the concept of enthalpy and enthalpy changes; 4) determine the thermochemistry equation; 5) determine the types of standard enthalpy changes; 6) determine the value of ΔH for the reaction through a calorimeter experiment; 7) determine the ΔH value of the reaction using standard enthalpy of formation data; 8) determine the value of ΔH for the reaction using Hess's law; 9) determine the ΔH value of the reaction using bond energy. From the results of these tests, it can be grouped students' difficulties in each indicator. The questionnaire sheet instrument consists of 20 statements based on five indicators that cause

learning difficulties in terms of learning methods. The interview aims to ask further questions or clarify students' answers to the questionnaire. Furthermore, the data obtained was analyzed using the descriptive analysis method.

From the data from the diagnostic test results, it can be determined the percentage of students who have learning difficulties per learning indicator, namely by using the calculation of the percentage (%) to find out the number (%) of students who have learning difficulties in each indicator with the following formula.

$$\%K = \frac{\text{Students answered incorrectly}}{\text{All the students}}\,100\%$$

Information:
%K = Percentage of students with learning difficulties for each indicator question [13].

Interpretation of students' learning difficulties can be seen in Table 1 as follows.

Table 1. Criteria of Student's Learning Difficulties

| Criteria | Percentage (%) |
|---|---|
| Very high | 81 – 100% |
| High | 61 – 80% |
| Fairly high | 41 – 60% |
| Low | 21 – 40% |
| Very low | 0 – 20% |

[14]

Then, the results of students' answers can be grouped from the level of understanding based on the diagnostic test questions. The grouping of these categories can be seen in Table 2.

In this study, questionnaire data was measured using a Likert scale. The answers to each instrument item use a scale that includes always, often, sometimes, rarely, and never. Students choose an answer by giving a mark checklist in one scale column. Then, the answers from each questionnaire item can be given a certain score, as listed in Table 4. Meanwhile, the interview data is used to complete the questionnaire results.

The questionnaire was analyzed quantitatively by comparing the total score obtained by the respondents with the total score multiplied by 100%. So, the results are expressed in percentage form with the following formula [16].

$$P = \frac{\Sigma F}{\Sigma N} \text{ x } 100\%$$

Then, the answers to each questionnaire item can be given a certain score, as listed in Table 3 below.

Table 2. Interpretation of Results Four-Tier Diagnostic Test

| Answer | Confidence Level of Answers | Reason | Confidence Level of Reasons | Category |
|---|---|---|---|---|
| True | High | True | High | Understand |
| True | Low | False | High | |
| True | High | False | High | |
| False | High | True | Low | |
| False | High | True | High | Misconception |
| False | High | False | Low | |
| False | Low | False | High | |
| False | High | False | High | |
| True | Low | True | Low | |
| True | High | True | Low | |
| True | Low | True | High | |
| True | Low | False | Low | Do not Understand |
| False | Low | True | Low | |
| False | Low | False | Low | |
| True | High | False | Low | |
| False | Low | True | High | |

[15]

Table 3. Scores for Questionnaire Item Criteria

| Criteria | Score Item (+) | Criteria | Score Item (-) |
|---|---|---|---|
| Always | 5 | Always | 1 |
| Often | 4 | Often | 2 |
| Sometimes | 3 | Sometimes | 3 |
| Seldom | 2 | Seldom | 4 |
| Never | 1 | Never | 5 |

[17]

## RESULT AND DISCUSSION
### Data Description

Research conducted at SMAN 13 Padang obtained data on learning difficulties based on the results of a diagnostic test given to students in class XI MIPA 6, a total of 34 people. Diagnostic test results of students are categorized into three groups, namely 1) students who understand the concept, 2) students who experience misconceptions, and 3) students who do not understand the concept. Students who have misconceptions and do not understand concepts are said to have learning difficulties [18].

Apart from using diagnostic tests, research data collection was also accompanied by filling out questionnaires and interviewing students. Giving a questionnaire aims to find out the causes of learning difficulties experienced by students in terms of how to learn. The way students learn is measured by five indicators: making schedules and implementing them, reading and making notes, repeating subject matter, concentrating, and doing assignments. The questionnaire used has 5 categories of assessment, namely always (SL), often (SR), sometimes (KD), rarely (JR), and never (TP). In contrast, the interview aims to ask further questions or clarify students' answers to the questionnaire.

## Student Diagnostic Test Results on Thermochemistry Material

The results of this study stated that according to students, the most difficult indicator was found in the sixth indicator, which was 90.20% with a very high category. The percentage of student diagnostic test answer categories can be seen in Table 4 below.

Table 4. Student Diagnostic Test Results

| Indicator | Category Answers Per-Indicator | | | |
| | PK (%) | TPK (%) | MK (%) | TP+MK (%) |
|---|---|---|---|---|
| 6 | 9.80 | 49.02 | 41.18 | 90.20 |
| 9 | 10.29 | 61.76 | 27.94 | 89.71 |
| 7 | 14.71 | 48.53 | 36.76 | 85.29 |
| 5 | 15.29 | 42.35 | 42.35 | 84.71 |
| 8 | 16.18 | 50.00 | 33.82 | 83.82 |
| 4 | 36.27 | 34.31 | 29.41 | 63.73 |
| 3 | 39.71 | 38.24 | 22.06 | 60.29 |
| 2 | 40.20 | 31.37 | 28.43 | 59.80 |
| 1 | 57.84 | 14.71 | 27.45 | 42.16 |
| Average | 26.70 | 41.14 | 32.16 | 73.30 |

Information: PK: Understanding the Concept, MK = Misconception, TPK = Not Understanding the Concept

Based on the average percentage of each category of answers per student indicator in Table 4, it can be seen in the diagrammatic Figure 1.
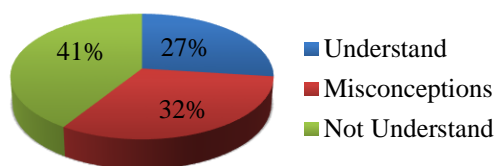
Figure 1. Categories of Student Answers

In Figure 1 it can be seen that the percentage of students who understand concepts, misconceptions, and do not understand concepts is 27%, 32%, and 41%. So, the percentage of students' learning difficulties is 73%.

The learning difficulties experienced by students in the 1st indicator were since students still had difficulty distinguishing examples between the system and the environment, which was 42.16% in a fairly high category. Students answer incorrectly due to inaccuracies and wrong understanding in determining examples that include systems and environments in an experiment. Students experience misconceptions because students only memorize the notion of the system and environment without understanding the differences, so when given examples of questions, students still need help distinguishing systems and environments [19].

The second indicator, learning difficulty, is quite high. This is because students experience an inverse concept between exothermic and endothermic reactions. Students still need to be corrected in determining the application examples of exothermic or endothermic reactions. In addition, the participants experienced students, namely 59.18% of the category of students, still needed to be corrected in determining the differences in exothermic and endothermic reactions in an experiment. Misconceptions experienced by students regarding indicators of exothermic and endothermic reactions affect the emergence of misconceptions on indicators of various standard enthalpy changes. Students cannot give the correct sign to the enthalpy change because students do not understand that releasing heat means a negative enthalpy change while receiving heat means a positive one [20].

The third indicator is that students experience learning difficulties at 60.29%, with a fairly high category. Students must understand the concept of enthalpy and enthalpy changes correctly and precisely. Most students also still need help in balancing reaction equations.

The 4th indicator, the learning difficulties experienced by students, is 63.73% in the high category. The difficulties experienced by students in this indicator are due to the possibility that students do not know the molecular formula of a compound or element. As in question number 7, to determine the

thermochemical equation of acetylene gas, students must first know the molecular formula of the acetylene gas. In addition, students still need help determining the reaction equation and or balancing the reaction equation for forming nitrous oxide gas.

The 5th indicator, the learning difficulties experienced by students, is 84.71% in the high category. The difficulties experienced by students were caused because students needed to understand the concept of the types of standard enthalpy changes such as standard formation enthalpy changes and standard decomposition enthalpy changes correctly. The standard enthalpy change of formation is the heat change resulting when 1 mol of a compound is formed from its elements at 1 atm pressure. The standard enthalpy change of decomposition is the heat change produced when 1 mol of a compound decomposes into its elements at a pressure of 1 atm [21]. In addition, students also experience difficulties making and equalizing the reaction equation of a compound contained in the problem.

The 6th indicator, students experience learning difficulties of 90.20% with a very high category. It is due to the possibility that students still have difficulty applying the formula, where determining the value of the $\Delta H$ reaction can be known from the quotient between the amount of heat required and the number of moles of reaction ($\Delta H = -Q/n$). If the reaction is exothermic, then the formula $\Delta H$ is accompanied by a negative sign. Conversely, if the reaction is endothermic, the formula $\Delta H$ is accompanied by a positive sign. In addition, students also still have difficulties in mathematical operations, converting units, and understanding the meaning of questions.

The 7th indicator, students experience learning difficulties of 85.29% with a very high category. The difficulties experienced by the students were probably due to the students' difficulty in writing the equation for the complete combustion reaction of propane gas. The students forgot to balance the thermochemical equation in determining $\Delta H$ for the complete combustion reaction of propane gas based on standard enthalpy change data of formation as in question number 22. Students also have the possibility of not knowing/forgetting the formula to be used, difficulties determining which is a product or a reactant in a chemical reaction, and difficulties in mathematical operations. To determine the enthalpy change for standard formation of a chemical reaction, students are led to be able to find out the equation of the chemical reaction that takes place, followed by the equalization of the chemical reaction. Based on this, the enthalpy change for a chemical reaction can be calculated from the standard enthalpy change data.

The 8th indicator, students experience learning difficulties of 83.82% in the very high category. Students need help determining the reaction's course based on Hess's law. Some students also need to correct their calculations. Students do not understand

the concept of determining the price ΔH reaction using Hess's law correctly and precisely.

The 9th indicator, the learning difficulties experienced by students are 89.71% in the very high category. The difficulties experienced by students are due to the possibility of students having difficulties in making and balancing chemical reaction equations such as equations for the decomposition reaction of NO gas2. In addition, students still have difficulty determining the molecular structure of an element or compound contained in the problem. Students may also need help applying the formula marked by the formula to determine the enthalpy change for a reaction based on the reverse bond energy. Students assume that to determine the enthalpy change for a reaction based on bond energy data using the same formula as determining the enthalpy change for a reaction based on the standard enthalpy change data. This is due to the need for students' understanding of the concept of thermochemistry material.

Based on the results of the diagnostic tests, it can be concluded that students have difficulty in expressing the concepts they are learning, difficulties in analyzing questions, and difficulties in mathematical operations. It can be seen from the number of questions given by many students who were able to answer correctly but needed help in giving the right reasons, and most students were also wrong in determining the right answers and reasons.

In line, thermochemistry is a difficult material [22]. Thermochemistry requires a deep conceptual understanding because it involves conceptual and algorithmic understanding. Students are expected to be able to understand the description of a concept and explain texts, diagrams, and phenomena that involve chemical concepts in thermochemistry. Students are also expected to be able to understand procedures involving mathematical calculations [23].

**Results Causes of Student Learning Difficulties in terms of Learning Methods**

Based on the questionnaire results, it was found that the factors causing students' learning difficulties in thermochemical material were caused by students' not implementing effective learning methods. The results of the questionnaire distribution analysis can be seen in Table 5.

In Table 5, the 3rd indicator (repeating subject matter) indicates that students do the least. Repeating subject matter is one of the causes of learning difficulties. Based on the results of the questionnaire analysis, the cause of students experiencing learning difficulties is that students "rarely" repeat or review a summary of the material they have learned. Students "rarely" repeat or re-learn thermochemical practice questions that have been studied. Following the results of the interviews, students repeated the subject matter when exams or daily assessments were held. If there is material that is not understood, students prefer to ask friends who understand thermochemical

material better than asking the teacher to explain it again. Students feel afraid or lack confidence when they want to ask the teacher. If students only ask friends, it is feared that there will be misunderstandings in the material.

Table 5. Result of the Questionnaire on the Causes of Learning Difficulties.

| Indicators | Score (%) | Average | Criteria |
|---|---|---|---|
| Scheduling and implementation | 64.85 | 3 | Sometimes |
| | 47.27 | 2 | Seldom |
| Read and take note | 45.45 | 2 | Seldom |
| | 47.88 | 2 | Seldom |
| | 44.24 | 2 | Seldom |
| | 55.15 | 3 | Sometimes |
| | 58.18 | 3 | Sometimes |
| | 52.12 | 3 | Sometimes |
| | 73.94 | 4 | Sering |
| | 86.67 | 4 | Sering |
| | 35.15 | 2 | Seldom |
| Repeating Study Materials | 49.70 | 2 | Seldom |
| | 43.64 | 2 | Seldom |
| Concentration | 67.27 | 3 | Sometimes |
| | 45.45 | 2 | Seldom |
| | 62.42 | 3 | Sometimes |
| Carry out a task | 58.79 | 3 | Sometimes |
| | 44.24 | 2 | Seldom |
| | 57.58 | 3 | Sometimes |
| | 88.48 | 4 | Often |

When associated with learning indicators, students experience the greatest learning difficulties in the sixth indicator because students rarely repeat subject matter after studying it at school. Students are required to repeat the subject matter at home because in solving questions related to mathematical operations, students cannot rely solely on the explanations given by the teacher. It follows the results of the analysis of questions and questionnaires, where the most difficult learning indicator is the sixth indicator regarding calculations, namely determining the value of ΔH for reactions through calorimeter experiments. The cause of the highest learning difficulties is students not repeating the subject matter.

Repeating greatly influences learning outcomes because, with repetition (review) of material that has yet to be well mastered, it will still be embedded in one's brain. It is necessary to provide time to repeat and make the best use of time to understand the material being repeated seriously [24]. Based on the results of diagnostic tests, questionnaires, and interviews, it was found that the way students learn greatly influences student learning outcomes. From the results of this study, the way students learn still needs to be implemented properly

and effectively. The better and more organized the learning method students use, the better and more consistent the learning outcomes obtained, and vice versa. If students' learning method is less precise and less organized, the learning results obtained will not be optimal [25]. Thus, students need to know how to learn effectively because student learning success can be achieved well if these students know how to learn effectively [26]. Based on these opinions, the way of learning significantly influences learning outcomes, so the way of learning is fundamental to encouraging and improving learning outcomes.

## CONCLUSION

Students of SMAN 13 Padang have difficulty learning thermochemical material. In the 1st, 2nd, and 3rd indicators, students experience learning difficulties with a fairly high category, namely 42.16%, 59.80%, and 60.29%. In the fourth indicator, students have learning difficulties, namely 63.73% in the high category. The highest learning difficulties experienced by students were found in the 5th, 6th, 7th, 8th, and 9th indicators, namely 84.71%, 90.20%, 85.29%, 83.82%, and 89.71% with very high category. Learning difficulties experienced by students are caused because students need to study more effectively, such as not making schedules and not carrying them out, not reading and not taking notes, not repeating subject matter, not concentrating on learning, and not doing assignments.

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