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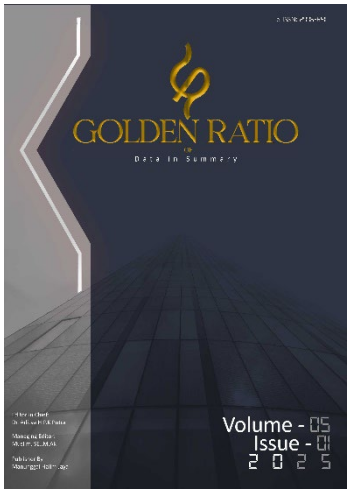

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Identification of Student Misconceptions on Photoelectric Effect Materials Using Four-Tier Diagnostic Test

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Abstract: This study aims to identify the level of misconceptions that occur in students by applying the four-tier diagnostic test method on photoelectric effect material. This research uses descriptive research with a quantitative approach. The samples of this research were 25 students of semester VII D and IX of physics education study program of Medan State University. The research instrument in the form of a four-tier diagnostic test using google form which consists of four levels, namely questions with one correct answer along with three exceptions, the level of confidence in the answer, the reason, and the level of confidence in the reason. The data collection technique used is by filling out the diagnostic test using. The data analysis technique used in this research is descriptive quantitative by finding the percentage of student misconceptions in each question. From the results of the study, it can be seen that students experience misconceptions in each question of photoelectric effect material with an average percentage of misconceptions of 34.67%. This percentage is classified as moderate category misconceptions. The highest percentage of misconceptions occurred in questions number 1 and 2 by 40%. The implication of this research is that educators can analyze the misconceptions experienced by students, and use suitable learning methods so that these misconceptions do not recur.

Keywords: Photoelectric Effect, Photoelectric Effect Misconceptions, Four-Tier Diagnostic Test, Quantum Physics Learning, Physics Education Students.

1. INTRODUCTION

Education is a learning process to equip oneself in the future obtained from new knowledge or experiences in life. Learning is an activity or interaction between individuals both as an educator and students to gain new knowledge, either through training or guidance. One of the learning that is difficult to understand is learning in the field of physics (Hasibuan et al., 2024). One of the things that needs to be prepared by the Physics Education Study Program in producing graduates who are ready to continue their studies to a higher level is knowledge and skills related to physics content. The Indonesian Physics Higher Education Association (APTIFINDO) has formulated a minimum standard of Graduate Learning Outcomes (SLOs) for physics education undergraduate programs in Knowledge element number 4 (P4), namely "Mastering physics concepts and physics scientific thinking patterns based on natural phenomena that support Physics learning in schools and master education programs". This means that graduates of the physics education undergraduate study program must master the concepts and scientific mindset not only for physics learning in schools, but also for master's education programs (Irvani et al., 2024). Each student has different abilities in connecting physics concepts with natural phenomena. Students can also experience errors when combining learned physics concepts, which can cause differences between their own concepts and those formed by experts, this is called misconception (Hatika et al., 2022). Misconceptions in one material may have an impact on learning difficulties in other materials, this is because the concepts in science are interrelated with one another. Most of the misconceptions are caused by several things

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including students themselves, teachers who teach, learning contexts, teaching methods, and textbooks. These five factors are important to consider in the implementation of lectures, especially for educational study programs that will graduate prospective educators. Accepted misconceptions are very dangerous because they will be passed on from generation to generation through the learning process (Pulu et al., 2023).

Therefore, misconception analysis must be done at the beginning of learning, so that teachers can plan the right learning process to overcome it. There are several ways that can be used to identify student misconceptions, one of which is with a diagnostic test. Using diagnostic tests can help teachers identify student misconceptions. Diagnostic tests are divided into several levels, namely one-tier diagnostic test, two-tier diagnostic test, three-tier diagnostic test, and four-tier diagnostic test. The evaluation of photoelectric effect material requires reasoning and the process of working to determine the right answer. When doing the evaluation, most students only choose answers without doing the work process so they do not know the reasons why they chose the answer. The implementation of such learning evaluations makes educators unable to dig deeper information about student answers. Therefore, educators need other forms of tests that can be used in evaluations with the aim of getting more detailed information about concept understanding and also student learning outcomes. An alternative solution that can be used to overcome this problem is to conduct an evaluation using the Four-Tier Diagnostic Test (FTDT) (Nurhafsari & Rismaningsing, 2023). Four-tier diagnostic test is a four-tier multiple-choice diagnostic test instrument that includes descriptive questions (first tier), confidence questions from the answers of the first tier (second tier), reasoning questions from the answers at the first tier (third tier), and student confidence questions in answering reasoning questions at the third tier (fourth tier) (Hasibuan et al., 2024). Four-tier diagnostic tests have advantages over previously existing diagnostic tests, among others: a) Can distinguish the level of confidence in student answers and the level of confidence in the reasons chosen by students so that they can dig deeper into the strength of student understanding. b) Diagnose misconceptions experienced by students in depth. c) Identify parts of the material that require more emphasis, and d) Design better lessons to help reduce student misconceptions (Nurhafsari and Rismaningsing, 2023).

2. RESEARCH DESIGN AND METHOD

The method used in this research is descriptive with quantitative research to obtain information and data that can be processed to understand the level of misconceptions of Medan State University students on photoelectric effect material. The approach in this research is a quantitative approach because the research results are represented in the form of numbers and after that analyzed using the Ms.excel 2010 program. The subjects of this study involved 25 students, namely the VII and IX semesters of the Physics Education study program at Medan State University. The selection of subjects was carried out who had studied topics related to the photoelectric effect in the quantum physics course.

The data collection technique in this study used a four-tier diagnostic test, which aims to identify students' level of understanding. Students were asked to answer a number of questions to evaluate their understanding of the concept of the photoelectric effect while measuring their level of confidence in the answers given. This test instrument is an objective test implemented through Google Form, with a four-tier diagnostic test format consisting of three questions. The first stage is a multiple choice question with four answer options. The second stage assesses students' level of confidence in the answer they chose in the first stage. Next, the third stage asks students to provide reasons for the answer they chose in the first stage, usually in the form of a choice of reasons that have been provided. Finally, the fourth stage evaluates the level of confidence (confidence rating) of students on the reasons they chose in the third stage (Putri and Subekti, 2021).

The data analysis technique of this study begins with analyzing the results of student answers on the test instrument. Students' answers are then grouped according to the four-tier diagnostic test answer categories understand the concept, do not understand the concept, misconceptions, errors.

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After that, the misconception level analysis was carried out to get the level of student misconceptions with the misconception percentage calculation formula, namely the number of students who experienced misconceptions divided by the total students who took the test then multiplied by one hundred percent (Nurhafsari and Rismaningsih, 2023).

$$P = \frac{f}{N} x100\%$$

P is the percentage of students who answered correctly, f is the number of students who answered correctly and n is the total number of students. Qualitative analysis was conducted by analyzing the students' reasons or explanations for the answers given. The grouping of students' misconception level is presented in Table 1.

Table 1. Grouping of Student Misconception Levels

Percentage of Misconceptions	Misconception Category
61% - 100%	High
31% - 60%	Medium
0%-30%	Low

Source: Hatika et al., 2022

3. RESULT AND DISCUSSION

Misconception diagnostic tests aim to identify misconceptions that students have. This test is used to evaluate the extent to which students understand concepts, especially those that are often misunderstood. The instrument used is a *four-tier diagnostic test*, which consists of four levels of questions. The first tier focuses on concept understanding, the second tier assesses students' confidence in their answers in the first tier, the third tier asks students to give reasons for the answers given in the first tier, and the fourth tier measures students' confidence in the reasons given in the third tier. This test helps distinguish between students who really understand the concept, do not understand the concept, or have a wrong understanding by looking at the combination of answers and the level of confidence of students in the answers and reasons they give (Hatika et al., 2022).

Table 2. Four-Tier Answer Combination Categories

Category	Answer Combination			
	Answer	Confidence Ratting Answer	Reason	Confidence Ratting Reason
Concept Understanding	Correct	Sure	Correct	Sure
Not Understanding the Concept	Correct	Sure	Correct	No
	Correct	Sure	Wrong	No
	Correct	No	Correct	No
	Correct	No	Wrong	No
	Correct	No	Correct	Sure
	wrong	Sure	Correct	No
	Wrong	Sure	Wrong	No
	Wrong	No	Correct	No
	Wrong	No	Wrong	No
Misconceptions	Correct	Sure	Wrong	Sure
	Correct	No	Wrong	Sure
	Wrong	Sure	Wrong	Sure
	Wrong	No	Wrong	Sure
Error	Wrong	Sure	Correct	Sure
	Wrong	No	Correct	Sure

Source: Maulida et al., 2023

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Based on the data that has been collected, data on the answers of each student is obtained. Furthermore, this data is processed and presented in tabular form. Analysis of student answers includes multiple choice answers, the level of student confidence in the answers chosen, the reasons for choosing these answers, and the level of student confidence in the reasons that have been chosen. The results of the analysis are then represented into 4 groups of concept understanding, namely understanding the concept, lack of understanding the concept, misconceptions, and errors. The categorization of Medan State University students' understanding of semester VII and IX on the material of Photoelectric effect is presented in Table 3.

Based on the data in Table 3, it can be stated that students experience misconceptions in photoelectric effect material. There are 49.33% students who understand the concept, as many as 16% students do not understand the concept, 34.67% students experience misconceptions, and 0% errors. The percentage of misconceptions in this study is in the moderate category (Hartika et al., 2022). The average percentage shows that students who understand the concept are more when compared to students who experience misconceptions. However, the percentage of students who experience misconceptions is more than students who do not understand the concept.

Table 3. Grouping Results of Student Concept Understanding

About	Percentage (%)				Category
	PK	KPK	M	E	
Understand the relationship between photon energy and electron kinetic energy in the photoelectric effect	40%	20%	40%	0%	Medium
Understand the relationship between light intensity and the number of electrons released in the photoelectric effect	48%	12%	40%	0%	Medium
Understand the relationship between light frequency and metal work function in the photoelectric effect.	60%	16%	24%	0%	Low
Average percentage	49,33%	16%	34,67%	0%	Medium

(Source: Researcher Data)

Description:
PK : Concept Understanding
KPK : Not Understanding the Concept
M : Misconceptions
E : Error

There are 3 types of questions tested on student participants, namely question 1 about understanding the relationship between photon energy and electron kinetic energy in the photoelectric effect, question 2 about understanding the relationship between light intensity and the number of electrons released in the photoelectric effect, and question 3 about understanding the relationship between light frequency and metal work function in the photoelectric effect. Students then worked on this *four-tier* test instrument through google *form* with four levels of answers, namely answers to multiple choices, confidence level in the answer, reasons for answering, and confidence level in the reasons given. The collected data were analyzed manually. The graph of the percentage of misconceptions in each multiple choice question on photoelectric effect material is presented in Figure 1.

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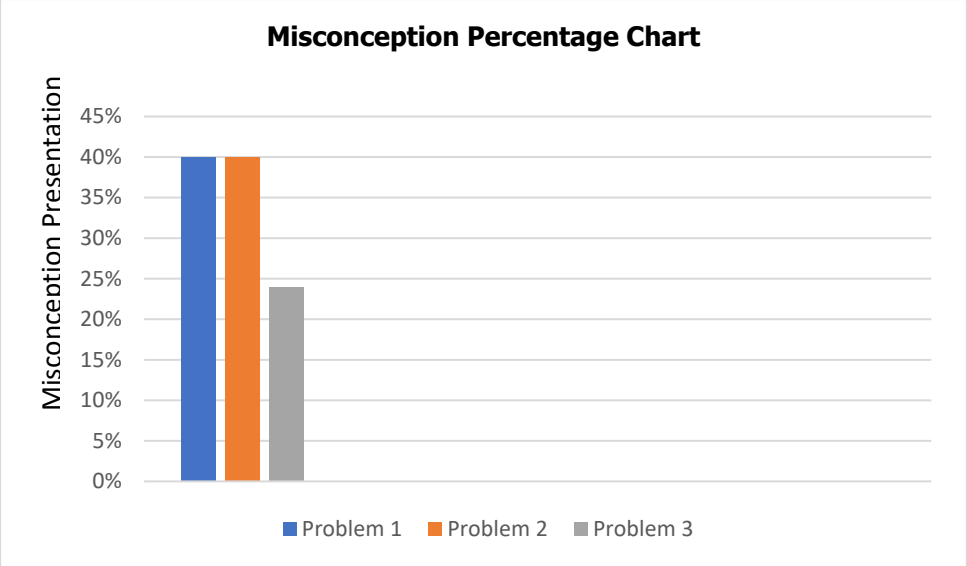

Figure 1. Graph of Average Percentage of Misconceptions

Based on the graph in Figure 1, it can be seen that misconceptions occur in all questions on the photoelectric effect. The largest percentage of misconceptions occurs in questions no. 1 and 2, namely understanding the relationship between photon energy and electron kinetic energy in the photoelectric effect and understanding the relationship between light intensity and the number of electrons released in the photoelectric effect. These misconceptions are classified as moderate. Furthermore, question number 3 is the question with the lowest level of misconception at 24% regarding understanding the relationship between light frequency and metal work function in the photoelectric effect. In this study, the percentage of misconceptions is classified as moderate, which indicates that there are still students who have difficulty in building and organizing concept understanding effectively. Misconceptions experienced by students can come from within the students themselves, namely due to errors in interpreting or inferring the concepts they learn. Students who are less active in the learning process tend to experience difficulties in the process of assimilating knowledge, so their understanding is not well developed. Conversely, the more active students are in participating in learning, the better and more comprehensive understanding they can achieve. In addition, another cause of misconceptions can come from the learning methods applied by lecturers. Unfocused methods can make students misinterpret certain concepts. In fact, misconceptions can also come from the lecturers themselves if they do not fully understand the concepts being taught, so the information conveyed also contains misconceptions (Hatika et al., 2022).

4. CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the average percentage of students who experience misconceptions is 34.67% in the moderate misconception category. The highest percentage of misconceptions occurred in questions no. 1 and 2, namely understanding the relationship between photon energy and electron kinetic energy in the photoelectric effect and understanding the relationship between light intensity and the number of electrons released in the photoelectric effect by 40%. The misconception of 34.67% is a fairly large percentage and has the potential to continue to occur when students learn the next materials or courses. It is hoped that after the completion of this research, lecturers can analyze the misconceptions experienced by students, and use suitable learning methods so that these misconceptions do not recur. The authors would like to thank all those who have provided support and contributions in the implementation of this research. Special thanks go to fellow students, who are willing to be respondents in this study and provide the necessary data. The supervisor, for the direction, guidance,

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