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Identification of Tadris Biology Students Level Understanding and Misconceptions on the Material of Quantities and Units Using 3-Tier Diagnostic Method

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Abstract: The level of understanding and misconceptions of Tadris Biology students at Mataram State Islamic University has been analyzed. The tested sub-materials, including quantities, units, and measurements, are adjusted to the Student Semester Learning Plan in the Basic Physics Course. The method used was observation using the 3-tier Diagnostic Test. The 3-tier Diagnostic Test is a question consisting of multiple choice questions accompanied by statements of reasoning and confidence levels.. This method has three stages of student answers: concept answers, reasons, and confidence levels. Based on the results of diagnostic tests on students, it was obtained that the level of complete understanding of students was 23.53%, and the level of misconceptions was 23.53%. The level of misconception is 23.53%. Students experienced the greatest misconceptions in the physical quantities sub-material, which amounted to 52.94%, and the lowest in the measurement material at 5.89%. Most students believe that the angle is not a principal quantity, as indicated by the wrong student answers accompanied by the reasons and with a high confidence level-certainly a misconception because according to experts, the angle is also a principal quantity. Although the percentage of misconceptions is tiny, students still experience misconceptions in each submitter.

Keywords: Misconception; Quantities and units; 3-Tier diagnostic

Introduction

Physics learning is learning done by students by linking natural events around them. The purpose of learning physics is to master knowledge (concepts) (Park & Liu, 2021; Rahmawati et al., 2023). Physics is categorized as physical knowledge that occurs due to the abstraction of the natural world. Physics learning is related to the mastery of concepts related to nature (Busyairi & Zuhdi, 2020; Maison et al., 2020).

Each student has a different power in connecting physics concepts with natural events. Students can also experience errors in connecting the physics concepts they learn; it can cause differences between the concepts they form themselves and the concepts formed by experts (Bhaw et al., 2023; Shidik & Tae, 2022). Students have different ways of building abstractions of physics concepts. A person's interpretation of a concept is called a conception (Afriwardani et al., 2023; Didik et al., 2020; Didik & Aulia, 2019).

The concepts brought by students can be in accordance and not following scientific concepts. If there is a difference between the concepts built by students and the concepts of experts, a misconception will be formed (Kordaki & Psomos, 2015; Pratiwi et al., 2023). Misconception is a pattern of thinking consistent in a different situation or problem, but the pattern of thinking is wrong (Korganci et al., 2015). Misconceptions occur a lot, especially for students with less ability to analyze. Usually, misconceptions occur to students when connecting a concept consisting of several basic concepts, requiring a deeper understanding. Concept

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understanding is one of the critical factors in physics learning (Korganci et al., 2015). Students not only memorize physics material but students are also expected to be able to know the role and benefits of physics as an applied science in life (Djanette, & Fouad, 2017; Kaltacki-Gurel et al., 2017).

One of the physics materials that become mandatory teaching for students, in general, is the quantities and unit (Wati et al., 2021). This material is taught in introductory physics courses for physics students and MIPA students other than physics, such as mathematics, chemistry, biology, engineering, and health majors. However, like other physics materials, the material of quantities and units is also often inseparable from students who experience misconceptions. Level of student misconceptions to determine many diagnostic methods are used (Soeharto & Csapo, 2022; Utami & Khotimah, 2023).

Diagnostic tests are used as an effort to find students' misconceptions. Diagnostic tests with a misconception approach identify students' ability to capture a concept they build based on their learning experiences (Irwansyah & Sukarmin, 2018). Misconceptions in students can be measured in various ways, namely by making concept maps (Sheftyawan et al., 2018), diagnostic tests (Rahmawati et al., 2023), interviews, classroom discussions (Im & Jitendra, 2020), and practicum through question and answer (Didik & Aulia, 2019; Kordaki & Psomos, 2015).

The 3 tier test diagnostic instrument with aspects of science literacy is used to reveal and find the form of students' science literacy misconceptions (Kustiarini et al., 2019; Mufida et al., 2023). The measure of the respondent's level of confidence in answering each question (question) given, which was developed to be able to distinguish between students who have misconceptions and do not know the concept, is called the certainty of response index (CRI) (Korganci et al., 2015; Stefanutti et al., 2020).

Many studies have analyzed misconceptions in students. Didik et al. (2019) analyzed misconceptions in physics tardis students on static electricity material. Didik et al. (2020) also analyzed tardis physics students' misconceptions about dynamic electricity. However, there is still no research on identifying Biology Education students' misconceptions about the material of quantities and units. This is because basic physics is a compulsory science that must be owned by science students including biology education students. misconceptions about physics can result in biology education students experiencing errors in research such as writing down measurement results and using the correct units in research.

Method

This research is a survey research. The research questionnaire distributed three questions to students with quantities, unit, and measurement indicators. This research was conducted at the Tadris Biology Study Program, State Islamic University (UIN) Mataram. The sample was taken from the first semester students of Tadris Biology Study Program odd semester academic year 2023/2024, which amounted to 34 people.

The test used in this study is a diagnostic test with a 3-tier diagnostic method. The questions used are concept questions with optional True or False answer types accompanied by answer explanations and confidence levels. This test is made to find out the type of student error, which in this research is about misconceptions (Didik et al., 2020; Didik & Aulia, 2019). Criteria for Assessing the Misconceptions of Tadris Biology Students as shown in Table 1.

Table 1. Criteria for Assessing the Misconceptions of Tadris Biology Students

Feedback Type	Category
Correct answer + Correct Reason + confident	FU
- Correct answer + Correct Reason + not sure - Incorrect answer + Correct Reason + not sure - Correct Answer + Incorrect Reason + not sure - Incorrect answer + Correct Reason + sure - Correct Answer + Incorrect Reason + sure	PU
Wrong answer + wrong reason but still related to the cause wrong reason + sure	M
- Wrong answer + wrong reason and unrelated to the cause of the reason chosen + sure - Wrong Answer + wrong reason and not related to the cause of the reason chosen + not sure - Wrong Answer + wrong reason but related to the cause of the reason chosen + not sure	NU

Where FU (Full understanding) is if students have full understanding, PU (Partially understanding) if students have partial understanding, M (misconception) if students have a different understanding from experts, and (Not understanding) if students do not understand at all about the material tested. The research instrument was prepared by reviewing the literature on the subchapters of quantities and units. In formulating the list of questions, paying attention to the logical sentence structure is necessary so that respondents can

understand the meaning contained in the question. In general, the research procedure is described in Figure 1.

Figure 1. Research procedure

Students are said to have misconceptions if they give answers and reasons incorrectly but have high confidence in giving answers. The percentage of misconceptions can be calculated with the equation 1 (Didik et al., 2020; Ko'o et al., 2022).

$$MS = \frac{n}{N} x\ 100\% \quad (1)$$

Where,
MS: Percentage of misconceptions
n: number of misconceptions
N: number of questions x number of students

Result and Discussion

In this study, the researcher was only an observer, while the magnetic electricity course lecturer carried out the learning process directly. The written test was given after all the material was given, so it was expected to reveal misconceptions that students on quantities, unit and measurement might experience.

Quantities, units and measurements are basic materials in physics. this material is important because science students will definitely do research so they need a discussion of how to make measurements and how to present measurement data. both materials are discussed in quantities, units and measurements. students will find it difficult to do research if they do not understand the basis of measurement and presentation of data. Therefore, it is necessary to observe the level of student understanding of these three materials. The concepts tested are shown in Table 2.

Table 2. Distribution of Misconception Questions Based on Semester Learning Plan (SSP) of Tadris Biology Study Program UIN Mataram

Indicators	Question number
Understand the concept of physical quantities	2
Understanding the concept of units	3
Understand the concept of measurement and presentation of results	1

Based on Table 2, it can be seen that the questions used are following the desired indicators in this study. Students' answers were then analyzed to understand the level of understanding and misconceptions of students (Turkoguz, 2020). The distribution of students' understanding of each Basic Competency is shown in Table 3.

Table 3. Percentage of Students' Concept Understanding Level of Tadris Physics UIN Mataram

Indicators	Level of Understanding (%)			
	FU	PU	M	NU
Understand the concept of physical quantities	5.89	29.41	52.94	11.76
Understanding the concept of units	41.18	41.18	11.76	5.89
Understand the concept of measurement and presentation of results	23.53	58.82	5.89	11.76
Average	23.53	43.14	23.53	9.80

Table 3 shows that the average complete understanding of Tadris Biology FTK UIN Mataram students reaches 23.53%, and 43.14% have partial understanding. Indicates that the level of understanding of Tadris Biologi students is quite good, although there are still many students who experience misconceptions, namely 9.80%. We reviewed the first material, which is about quantities. The level of understanding of tadris biology students on the quantities sub-material is shown in Figure 2.

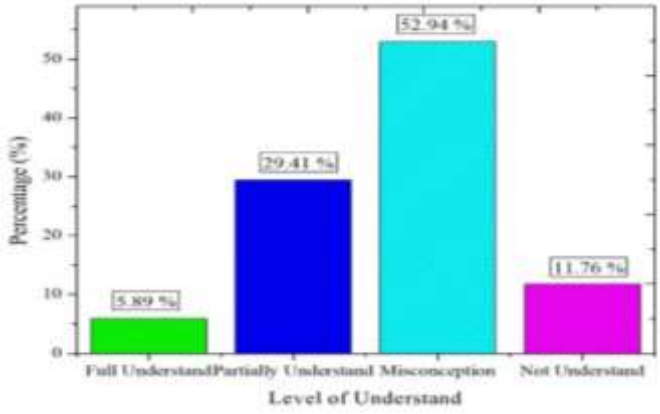

Figure 2. The level of understanding of tadris biology students on the subject of physical quantities

Figure 2 illustrates the level of understanding of tadris science biology students on the coulomb force sub-material physical quantities. In physical quantities sub-material, biology students' whole level of understanding only reaches 5.89%. The percentage of student misconceptions is relatively large, reaching 52.94%. Indicates that tadris biology students have not been able to distinguish the types of quantities comprehensively. Most students believe that the angle is not a principal quantity, as indicated by the wrong student answers accompanied by the reasons and with a high confidence level—certainly a misconception because according to experts, the angle is also a principal quantity.

Quantities is something that can be measured and has a large. in general, based on the magnitude of the quantities is divided into the principal quantities and derived quantities. Principal quantities are predetermined quantities while a derived quantity is a quantity that consists of several principal quantities like dielectric constant (Didik & Wahyudi, 2020).

In general, principal quantities consist of the amount of substance, light intensity, time, electric current strength, temperature, mass length, light and angle. Many student assume that the angle is a derived quantity. This is a misconception because the angle does not consist of several principal quantities. Many students think that because the angle is formed by two straight lines that have units of meters so the angle consists of two principal quantities of length. This is of course an error because the angle is not affected by length so the angle is a principal quantity. Next is the level of the students' understanding of the material in the physics units. The level of understanding of the concept of tadris biology students on the subject of physical unit is shown in figure 3.

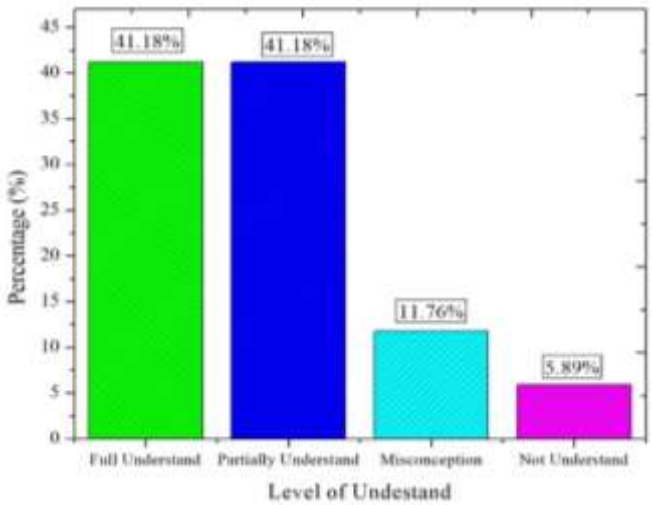

Figure 3. The level of understanding of the concept of tadris biology students on the subject of physical unit

Figure 3 illustrates the level of understanding of tadris biology students on the sub-material physical unit. In the physical unit sub-material, the complete understanding of tadris biology students reached 41.78%. The percentage of student misconceptions is relatively small, reaching 11.76%, but the percentage of students who understand partially is relatively high, reaching 41.18%. It occurs because students know the answer but do not know the reason. Many students do not know how to convert a quantity, such as Fahrenheit, to centigrade or vice versa. So far, learning in schools prioritizes memorization but is not taught how to explain concepts. There are many misconceptions among students, especially those with poor analytical skills (Bhaw et al., 2023).

It is very likely to happen when students analyze the measurement results. There are still students who cannot present measurement data. It certainly makes the student not understand the desired learning indicators.

Unit is a way to define a quantity. without a unit, the quantity has no value. in one quantity there are several units. the standardized units of a quantity are regulated in an international system. It is usually divided into two systems, namely MKS (metre, kg, secon) and CGS (centimetre, gram, secon) units. for example, the amount of energy has joule units in the MKS system and erg in CGS units. therefore we recognize the conversion to change the MKS unit of a quantity into the CGS unit of the quantity.

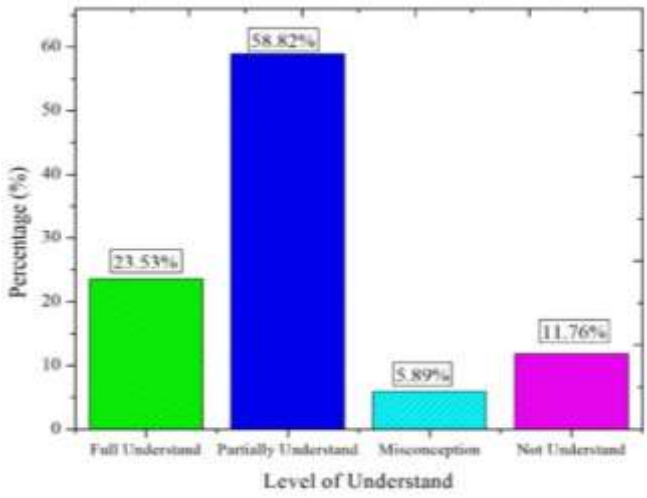

Figure 4. The level of understanding of the concept of tadris biology students on the subject of physics measurement

Figure 4 illustrates the level of understanding of Tadris biology students on the measurement sub-material. In the measurement sub-material, the level of complete understanding of physics students is relatively low, reaching 23.33%. The percentage of student misconceptions is also low, reaching 5.89%. However,

the number of students who only partially understand is relatively high, reaching 58.82%. It is pretty ironic because the analysis of material on measurement is material that students often practice. The cause of the low level of understanding of students may be due to the large number of students who do not know how to present the measurement results, as shown in Figure 6. Many students think the tool's accuracy is similar to the most minor scale. In contrast, we know that the accuracy is half the minor scale in equation 2.

$$\Delta x = \frac{1}{2} \text{ smallest scale value} \quad (2)$$

In this study, students are considered to have misconceptions if they have wrong answers and reasons but have high confidence in their answers. The causes of misconceptions experienced by students can be grouped into five things, namely: students (Busyairi & Zuhdi, 2020), lecturer (Wahyudi et al., 2021), Textbook (Nurfiyani et al., 2020), context (Widarti et al., 2021), and teaching methods (Maison et al., 2020).

The challenge of addressing misconceptions in learning is significant. Teachers must understand that misconceptions are not students' mistakes, but are part of the learning process. The first challenge is detecting misconceptions. Often, misconceptions are difficult to spot because students may not realize that they have a wrong understanding. The comparison of student misconceptions in other physics materials is shown in Table 4.

Table 4. Comparison of misconceptions in students with different materials

Materials	Object	Percentage of misconception (%)	References
Quantities, units, and measurement	Biology teacher candidate	23.53	This research
Static Electricity	Physics teacher candidate	23.67	(Didik & Aulia, 2019)
Dynamic Electricity	Physics teacher candidate	43.71	(Didik et al., 2020)
Straight motion	Physics teacher candidate	67.00	(Busyairi & Zuhdi, 2020)
Vertical Motion	Physics teacher candidate	53.00	(Busyairi & Zuhdi, 2020)
Parabolic motion	Physics teacher candidate	57.00	(Busyairi & Zuhdi, 2020)

Several causes come from students, including students' ability, interest, and way of thinking and the influence of friends. The causes of lecturer errors include lack of mastery of concepts, lack of teaching preparation, inappropriate teaching methods, and lack of attitude of lecturers, resulting in a lack of relationship with students. The context in question is the existence of a general assumption, which is a misconception so that it is followed again by students (Aini et al., 2023; Hunaidah Hunaidah et al., 2022).

Teaching methods that only emphasize one aspect of thinking can also lead to misconceptions in students, especially for units. Students can use many steps or ways to solve the unit case.

There are several ways to overcome misconceptions in students such as identifying misconceptions that often occur in the material being taught (Ningrum et al., 2022). Other things that can be done such as attractive teaching methods and feedback to students (Jumilah & Wasis, 2023). In addition, it can also be done with project-based learning or by carrying out practicum (Meiliyadi et al., 2023).

Conclusion

The average level of complete understanding of Tadris Biology UIN Mataram students reached 23.53%, and 23.53% of students experienced misconceptions. In the magnitude sub-material, the level of complete understanding of students is only 5.89%. The percentage of student misconceptions is quite large, reaching 52.94%. In the unit sub-material, the entire understanding of physics students reached 41.18%, while the percentage of student misconceptions was quite large, reaching 11.76%. In the measurement sub-material, the level of complete understanding of physics students is relatively low, reaching 23.53%. The percentage of student misconceptions reached 11.76%. However, the number of students who only partially understand is relatively high, reaching 58.82%.

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Author Contributions
LADM provides ideas for conducting research, AA makes research designs and collects data, and KA analyze data and LADM write discussions and conclusions.

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