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Misconceptions on biodiversity and protist using Three-Tier multiple-choice diagnostic tests

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ABSTRACT

Misconceptions are important to know, so that future learning can be improved. This study aims to identify students' misconceptions on the subject of Biodiversity and Protists. This type of research is descriptive quantitative. The sampling technique used in this study was purposive sampling, considering that students who had studied the material on Biological Diversity and Protists had not identified misconceptions and the geographical location of the research site. The research subjects were students of class X SMA Negeri in Kampar Regency, each in two classes, with a total sample of 405 students. The instrument used in the study was a Three-Tier Multiple Choice Diagnostic Test. The study results concluded that the average Percentage of students who had misconceptions about the material on Biodiversity was 32.44% (medium category), and the material Protista was 31.56% (medium category). In the material on Biological Diversity and Protists, many students experience false-negative misconceptions, which means that the information possessed by students is little or incomplete.

Introduction

Biology learning which contains many concepts requires students to understand, apply, analyze factual, conceptual, and procedural knowledge, and apply procedural knowledge to solve problems. One thing that must be achieved in learning biology is that students can think critically and understand concepts in biology first. According to Rochmad et al. (2018) Critical thinking skills need to be possessed by students, if students do not have critical thinking skills, it can cause students to have misconceptions and difficulty understanding existing concepts. Facts in the field found that to train students' critical thinking skills, they had several obstacles, including a lack of insight and motivation in learning, and inadequate learning resources in schools. In addition, students at school think that biology is a difficult subject to understand because the material is abstract and boring. Students who have difficulty understanding concepts in biology sometimes create concepts that are different from scientifically accepted concepts and the thoughts of experts, which can lead to misconceptions (Tekkaya, 2002). Misconceptions are related to ideas with

different perceptions and meanings in students' incorrect articulations (Bahar, 2020).

Misconceptions are concept-based errors (Ekawati & Rafiah, 2017). Misconception refers to the mistaken concept of knowledge that is considered accurate by individuals in learning scientific truths or obtained through personal experience (Raharjo et al., 2018). Based on the results of interviews in January 2021 with the Biology teacher at SMAN 1 Bangkinang Kota, the Biology teacher at SMAN 2 Bangkinang Kota, and the biology teacher at SMAN 1 Kampar, the biological material that experienced misconceptions was the material on Biological Diversity and Protists. As evidenced by the low scores on student exams, students feel bored studying the material on Biodiversity at the gene level, species level, and ecosystem level, and the habit of memorizing the material. according to the opinion of (Imaningtyas et al., 2016), the misconception of Biodiversity material occurs because teachers tend to give incorrect explanations of material without providing contextual examples around students' lives. Internal factors that influence students' misconceptions are experience, observations, thinking skills, and language skills (Eitel et al., 2021; Maryati & Priatna, 2018; Subekti et al., 2021). Other factors that cause misconceptions are students, teachers, teaching materials, context, and methods (Imaningtyas et al., 2016; Suparno, 2005; Tekkaya, 2002). The same thing was also stated by Yunanda et al. (2019) that the highest misconception on Biodiversity material is found in the Diversity Damage Threat Indicator of 13.25%.

In Protista material, students have difficulty understanding too dense material, so it requires high understanding, and teachers at school do not encourage students to think at a higher level. This is to the opinion Murni (2013) that the misconception of Protist material is caused by the fact that the Protista species are only seen from the pictures presented by the teacher, textbooks, or the internet, not seeing the object directly, so students experience misconceptions. The highest misconception of Protist material was found in the identification indicators of general animal-like protists at 26.28% (Yunanda et al., 2019). Student misconceptions can be identified in various ways, namely through interviews, concept maps, diagnostic tests, and a combination of tests with clinical interviews (Bayuni et al., 2018; Murni, 2013; Tayubi, 2005). One of the methods researchers used to identify students' misconceptions is to use a diagnostic test, namely the Three-Tier Multiple Choice Diagnostic Test. This Three-Tier Multiple Choice Diagnostic Test can detect a lack of knowledge percentage by using a confidence rating. The Three-Tier Multiple Choice Diagnostic Test enables teachers to gain information about students' misconceptions and understanding of concepts and provides a foundation for developing valid and reliable diagnostic assessment tools (Caleon & Subramaniam, 2009).

Three-Tier Multiple Choice Diagnostic Test consists of three levels, namely the first-level students are asked to choose the right answer, the second-level students are asked to choose the reason for the answer at the first level, and the third level is the confidence level of choice at the first level and second level (Cetin-Dindar & Geban, 2011). Three-Tier Multiple Choice Diagnostic Test This has the advantage that it is proven to be accurate in measuring students' misconceptions, can observe the effectiveness of student learning, can measure students' conceptual understanding, can measure the Percentage of students who do not understand the concept, and can distinguish misconceptions accompanied by the two previous questions (Peşman & Eryılmaz, 2010). Based on this description, this study aims to identify students' misconceptions about the material on Biological Diversity and Protists by using Three-Tier Multiple Choice Diagnostic Test.

Method

This research is quantitative descriptive research. Quantitative data analysis was obtained from the Percentage of students' incorrect answers on each item. This study aims to identify students' misconceptions on the subject of Biodiversity and Protists. The population of this research is the students of class X SMA Negeri in Kampar Regency. The sampling technique was purposive sampling, considering that students who had studied the material on Biological Diversity and Protists had not identified

misconceptions and the geographical location of the research site. The number of samples in the study was 405 students, which is listed in Table 1. The sample class was taken based on an agreement with the subject teacher. The study was conducted in April-May 2021.

Data collection misconceptions using Three-Tier Multiple Choice Diagnostic Test. The Three-Tier Multiple Choice Diagnostic Test that researchers use in research is adopted from (Yunanda et al., 2019), which uses the research stage according to Treagust (1988). Compilation of Three-Tier Multiple Choice Diagnostic Test created by Yunanda et al. (2019) based on the Regulation of the Minister of Education and Culture Number 37 of 2018, on basic competencies (KD) 3.2, 4.2, 3.6, and 4.6. Table 2 is an example of a Three-Tier Multiple Choice Diagnostic Test, which was adopted by Yunanda et al. (2019).

Table 1. Several research samples

No	School name	Total
1	SMAN 1 Bangkinang Kota	71
2	SMAN 2 Bangkinang Kota	63
3	SMAN 1 Kampar	72
4	SMAN 1 Kuok	34
5	SMAN 2 Tambang	42
6	SMAN 1 Kampar Timur	68
7	SMAN 1 Kampar Utara	55
The total of students		405

Table 2. Examples of three-tier diagnostic instruments for biodiversity and protists

Basic competencies	Indicators of competency achievement	Question indicator	Question	Answer key
3.2 Analyzing the various levels of Biodiversity in Indonesia and their threats and conservation	3.2.1 Analyzing various levels of Biodiversity in Indonesia	3.2.1.1 Analyzing Biodiversity at the gene level by differentiating two organisms	*Felis silvestris* (wild cat) and *Felis catus* (pet cat) are biodiversities caused by … a. Gene variation b. Color variations c. Shape variations d. Type differences e. Size difference The reason you chose the answer above is … a. The genes in the two cats above are different so that they form cat diversity b. Color can be used to differentiate between species and shape the biodiversity in cats c. Body shape shows biodiversity in the two cats above d. The difference in species is stated in the classification, namely the species names of the two cats are different e. The body size of the two cats is different, indicating the biodiversity in cats How do you feel about the selected answer? a. Sure b. Not Sure	Tier 1: A Tier 2: A
3.6 Classify Protists based on general characteristics of the class and relate their role in life	3.6.5 Analyzing the role of Protists in everyday life	3.6.5.1 Analyzing the detrimental role of animal-like protists by presenting the characteristics of the disease caused and being asked to name the species that causes the disease	Diseases that endanger pregnant women and their vectors are cats, caused by: … *a. Giardia lamblia* *b. Toxoplasma gondii* *c. Plasmopara viticola* *d. Leishmania donovani* *e. Trichomonas vaginalis* The reason you chose the answer above is that parasites live in … a. Cat blood b. Cat's intestines c. Cat fur d. Cat muscle tissue e. Cat body glands	Tier 1: B Tier 2: B

	How do you feel about the answer you have chosen?? a. Sure b. Not Sure

Table 3. Criteria for determining misconceptions

No.	Category	Response type		
		Tier 1	Tier 2	Tier 3
1	Understand concept	Right	Right	Sure
2	Guess	Right	Right	Not sure
3	Misconception (false positive) (FP)	Right	False	Sure
4	Don't understand the concept (lack knowledge) (type 1)	Right	False	Not sure
5	Misconception (false negative) (FN)	False	Right	Sure
6	Don't understand the concept (lack knowledge) (type 2)	False	Right	Not sure
7	Misconception (false negative) (FN)	False	False	Sure
8	Don't understand the concept (lack knowledge) (type 3)	False	False	Not sure

Source: (Peşman & Eryılmaz, 2010)

Table 4. Categories of misconceptions

Misconception percentage range	Category
0% < misconception < 30%	Low
30% < misconception < 70%	Medium
70% < misconception < 100%	High

Source: (Kurniawan et al., 2016)

Analysis of research data is the Percentage of students' misconceptions, as for the steps to determine students' misconceptions. After Correcting student answers based on the answer key, then Identify students' misconceptions using a three-tier diagnostic instrument, which is useful for distinguishing the condition of students' concepts.

The data analysis technique used is the type of data obtained from the results of students' incorrect answers on each item. The results of incorrect answers on each item stated quantitative data. Quantitative data was obtained from the Percentage of students' incorrect answers on each item. The following equation I the Percentage of each answer choice and reason.

$$P = \frac{S}{JS} X\ 100\% \qquad \text{(I)}$$

The explain of this equation: percentage of students who have misconceptions (P), number of students who have misconceptions (S) and total number of students (JS). Determining the criteria for students' misconceptions is listed in Table 3.

Classifying misconceptions in students, by classifying misconceptions based on the percentage results for each measured competency achievement indicator. Determining the category of misconceptions can be seen in Table 4.

Results and Discussion

The data analysis technique used is the type of data obtained from the results of students' incorrect answers on each item. The results of incorrect answers on each item stated quantitative data. Quantitative data was obtained from the Percentage of students' incorrect answers on each item. The following formula calculates the Percentage of each answer choice and reason. The results of the identification of misconceptions using the Three-Tier Multiple Choice Diagnostic Test on Biodiversity material are listed in Table 5, the average Percentage of students who understand the concept is 22.91%, the average Percentage of students guessing is 1.74%, the average Percentage of students experiencing misconceptions is 32.44%, and the average Percentage of students who do not understand the concept is 10.47%. The highest percentage of misconceptions is found in biodiversity conservation efforts, namely false-negative misconceptions as much as 57.20% including in the medium category.

The results of identifying misconceptions of Protist material using the Three-Tier Multiple Choice Diagnostic Test can be seen in Table 6. This shows that the average Percentage of students understanding the concept is 15.41%, the average Percentage of students guessing is 1.93%, the average Percentage, the average percentage of students who experience

misconceptions, is 31.56%, and the average Percentage of students who do not understand the concept is 19.53%. The highest Percentage of students who experience misconceptions is found in the indicators of the general Characteristics of Fungus-Like Protists, namely false-negative misconceptions of 50.33% in the medium category.

Based on the results of the identification of misconceptions on Biodiversity material listed in Table 5, it shows that the average Percentage of students who experience misconceptions is 32.44% which is included in the category of moderate misconceptions. Students experience the highest misconceptions on false-negative misconceptions, where students answer wrongly on the first tier and answer correctly on the second tier which means that the information obtained by students is little (Hestenes & Halloun, 1995). In the indicators of the level of Biodiversity, questions are presented in the form of gene level, species or type level, ecosystem level, and the benefits of Biodiversity. It was found that students who experienced false positive misconceptions were 12.17%, while students who experienced false negative misconceptions were 49.75%. On the indicator of the level of Biodiversity, most students gave the wrong answer in the first tier, and in the second-tier students gave the correct answer. This is caused by students who are still wrong in distinguishing Biodiversity at the gene, type/species, and ecosystem levels. If students continue to experience misconceptions, it means that students do not understand concepts well or students only understand some concepts (Caleon & Subramaniam, 2009).

According to Yunanda et al. (2019), the cause of the misconception on the level of Biodiversity is that teachers are more likely to ask students to read textbooks containing examples of differences in Biodiversity in general, and the information contained in textbooks is outdated and not contextual. In addition, the teacher does not carry out practical work, such as small observations in the school environment to determine differences at the gene level and the level of species or types. One example of a small observation that teachers in the school environment can make is to invite students to see the types of mango and durian plants in the school environment. If observations are made in the school environment, it can improve contextual learning to form meaningful learning, and students do not learn by the rote system (Septian et al., 2018).

The indicator of the threat of damage to biodiversity shows that the average Percentage of students who experience false-positive misconceptions is 17.25%, and the average Percentage of students who experience false negative misconceptions is 42.74%. In the indicator of the threat of damage to biodiversity, students are given questions to analyze the threat of damage to biodiversity at the gene level, species level, and ecosystem level. Some students answered incorrectly in the first tier and answered correctly in the second tier. This means that students have little information or understand only a few concepts. As stated by Lambi and Elizabeth (2009), the main cause of the misconception of the Threat of Biodiversity Damage is that the learning provided by the teacher does not integrate information on the latest natural conditions and natural conditions around students' lives. Besides that, the teacher only focuses on information and examples contained in textbooks and does not look for other sources. Examples of renewable natural conditions are the phenomenon of red glowing objects that fall from the sky in the Simpang Lancang area, and examples of natural conditions around students' lives, namely rivers that are polluted due to the accumulation of garbage.

Table 5. Results of identification of misconceptions on biodiversity materials

Indicator	Question number	P (%)	TB (%)	Misconception		TP (%)
				FP (%)	FN (%)	
Biodiversity level	1, 2, 3, 4, 5, 6	25.91	1.90	12.17	49.75	10.27
The threat of biodiversity damage	7, 8, 9, 10, 11	27.87	2.02	17.25	42.74	10.12
Biodiversity conservation efforts	12, 13, 14, 15	14.97	1.30	15.52	57.20	11.01
Average (%)		22.91	1.74	14.98	49.90	10.47
				32.44		

Information: P (understand the concept), TB (guess), FP (false positive), FN (false negative), TP (don't understand concept)

False-positive misconceptions experienced by students are 15.52%, and false-negative misconceptions are experienced by students as much as 57.20%, on the indicator of Biodiversity Preservation Efforts. The questions given to students aim to determine students understanding of Biodiversity Preservation Efforts. However, most students answered correctly on the first tier and incorrectly answered on the second tier, which means that in this condition students do not understand the concept of Biodiversity Preservation Efforts. Students own the wrong concept, making students' level of concern for the surrounding environment low, so it is not integrated with students' daily lives and students cannot provide solutions or efforts to preserve nature (Pooley & O'Connor, 2016).

Based on the results of identifying misconceptions using a three-tier diagnostic instrument on the Protista material listed in Table 6, it shows that the average Percentage of students who experience misconceptions is 31.56% including those in the medium category. Many students experience false-negative misconceptions, which means that the information obtained by students is little (Hestenes & Halloun, 1995). Indicators of general characteristics of animal-like protists, students experience misconceptions of 18.08% of false positive misconceptions, and 36.42% of false negative misconceptions. In the general characteristics indicators of plant-like protists, students experience false positive misconceptions as much as 9.46%, and false negative misconceptions as much as 46.90%. As indicators of general characteristics of mushroom-like protists, students experience misconceptions as much as 22.64% of false positive misconceptions, and 50.33% of false negative misconceptions. On indicators of general characteristics of protists such as animals, plants, and fungi, most students answered incorrectly on the first tier and answered correctly on the second tier, which means that students still experience confusion in identifying Protists based on their characteristics and students tend to learn to memorize their characteristics. by Protists. As stated by Mukaromah et al. (2012); Raharjo et al. (2018); Riki et al. (2018) that students tend not to understand the characteristics of each group of plant-like protists, because students only memorize the terms contained in the material, besides that students have difficulty in distinguishing the locomotion owned by each group of animal-like protists, and also students do not understand the concept the life cycle of each group of fungus-like protists.

Students experience false-positive misconceptions as much as 14.81%, and false-negative misconceptions as much as 49.88%, on the indicators of the classification of protists similar with animals, plants, and fungi. In the classification problem of protists like animals, plants, and fungi, most students answered incorrectly on the first tier and correctly on the second tier. Based on observations in class, students tend to classify protists like fungi, plants, and animals through pictures found in textbooks and the internet pictures, rather than seeing them directly as in practical activities. In addition, teachers at schools can also use learning videos to explain the classification of protists such as animals, plants, and fungi. Learning by only looking at pictures without making direct observations can lead to misunderstanding concepts in students (Kaltakci Gurel et al., 2015). One example to reduce misconceptions that occur in students is by developing teaching materials in the form of e-modules that create justified concepts.

On the indicator of the role of Protista, students experienced false-positive misconceptions as much as 18.73%, and 48.37% in false-negative misconceptions. In the problem of analyzing the role of Protists, most of the students answered incorrectly on the first tier and answered correctly on the second tier, which means that in this condition, students have little information.

This is evidenced by the results of observations in the classroom that students only learn the role of protists through textbooks and the internet, and the teacher does not reinforce it by integrating it into students' daily lives, which results in students misunderstanding the concept of the role of protists. One example of a protist's role in students' daily lives is *Toxoplasma gondii*, an animal-like protist, where Toxoplasma gondii is a parasite in the intestines of cats and can harm pregnant women, which in turn will form cysts in various organs such as the brain, muscle, and heart. According to Zunitasari et al.

(2016), students only learn by memorizing the protist role material, which is beneficial and detrimental and can cause students not to understand the concept of the role of protists.

Teachers can use learning methods, models, and media that can improve the assimilation of student concepts in learning and accommodate the formation of appropriate concepts in students so that students do not experience misconception. Assimilation of concepts here is a cognitive process of integrating new perceptions or experiences into patterns that already exist in the mind. While accommodation is an adjustment to the formation of the concept of the newly acquired pattern with the old pattern that already exists in the mind to form a pattern of concepts that are aligned.

Table 6. Results of identification of protist material misconceptions

Indicator	Question number	P (%)	TB (%)	Misconception		TP (%)
				FP (%)	FN (%)	
General characteristics of animal-like protists	16, 17, 18	21.97	3.80	18.08	36.42	19.74
General characteristics of plant-like protists	19, 20, 21	25.21	1.34	9.46	46.90	17.09
General characteristics of fungus-like protists	22, 23	10.92	1.86	22.64	50.33	14.25
Classification of animal-like protists, plants, and fungi	24	6.91	0.99	14.81	49.88	27.41
The role of protists	25, 26, 27, 28, 29, 30	12.06	1.65	18.73	48.37	19.18
Average (%)		15.41	1.93	16.75	46.38	19.53
				31.56		

Information: P (understand the concept), TB (guess), FP (false positive), FN (false negative), TP (don't understand concept)

Conclusion

Based on the results of the study, it was concluded that the average Percentage of students who had misconceptions about the material on Biodiversity was 32.44% which was included in the medium category, while the average percentage of misconceptions about the Protista material was 31.56% which was included in the medium category. The highest misconception on Biodiversity material occurs in the indicators of Efforts to Preserve Biodiversity as much as 57.20%. In Protists, the highest misconception occurs in the indicators of general Characteristics of Fungus-Like Protists by 50.33%. Suggestions from researchers to prevent misconceptions in students is to make teaching materials in the form of e-modules, where e-modules contain concepts that have been justified by literature studies. In addition, teachers can use models and methods in the learning process to prevent misconceptions.

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