Biosfer: Jurnal Pendidikan Biologi

Analysis of student misconceptions on cell material as the smallest unit of life

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ARTICLE INFO

ABSTRACT

This study aims to determine students' misconceptions on cell material as the smallest unit of life and the factors that cause misconceptions. The research method used was descriptive quantitative. The sample in this research amounted to 35 students who were taken using random sampling techniques. The four-tier diagnostic test was used as an instrument to determine students' misconceptions and the factors that caused the misconceptions were known through interviews. The results showed that students experienced misconceptions in the amount of 36.03% with the moderate category, where the highest misconception occurred in the indicator of analyzing the membrane transport mechanism by 48.57%, and the lowest misconception occurred in the indicator explaining the chemical components of a cell by 28.57%. The main factors causing misconceptions were are textbooks, friends, and the internet.

INTRODUCTION

Misconceptions are inaccurate understanding of concepts, use of incorrect concepts, incorrect classification of examples of concepts, confusion between different concepts, and inappropriate hierarchical relationships between concepts (Fowler &Jaoude, 1987). Misconceptions can prevent students from mastering more deeply about a material, hindering the process of receiving and integrating new knowledge Yunanda, et al., 2019; Zulfia, et al, 2019). It is known that the concepts in biology are interrelated and are the key to understanding other concepts. therefore, if misconceptions are not resolved immediately, it can lead to misconceptions in other concepts (Tekkaya, 2002). This will have an impact on the achievement of low science scores (Septiana et al., 2014). When viewed from the 2018 PISA (Program for International Student Assessment) data, Indonesia is in the 70th position out of 78 countries and has a score below the average PISA standard (OECD, 2019).

Misconceptions that occur in students, prospective teachers and teachers regarding biology materials have been widely reported. Köse (2008) revealed misconceptions in the material of photosynthesis and cellular respiration through direct interviews with students. Barak et.al (1997) found misconceptions in energy material through questionnaires given to teachers and students. Yip (1998) reported misconceptions on circulatory system material through written tests in the form of short questions. The detection of misconceptions of cell division material was stated by Newman et.al (2012) using ordinary multiple choice tests and open tests. Interviews, open tests and common multiple choice have some drawbacks in uncovering misconceptions (Peşman&Eryilmaz, 2010). A four-level multiple-choice test can distinguish between the confidence level of the answers and the confidence level of students' choice of reasons so that it can dig deeper about the misconceptions experienced by students (Rusilowati, 2015).

Misconceptions can come from the students themselves, which are related to their experiences (Chhabra &Baveja, 2012), the ability to analyze and link several concepts (Mentari &Subagia, 2017), associative thinking (Marshall & Gilmour, 1990), initial knowledge, and activeness. in learning (Sopiany&Rahayu, 2019). In addition, factors from outside students such as teachers can also lead to misconceptions (Halim& Mustafa, 2019). A preliminary study has been carried out by providing a four-tier diagnostic test (FTDT) to find out the biology material for odd semesters that shows symptoms of misconception. The preliminary study revealed that the biggest misconception was found in the learning material of cells as the smallest unit of life by 69% where students could not distinguish the function of mitochondria and chloroplasts. Based on the results of the interview, it was also known that the teacher had never revealed misconceptions that occurred to students. This study aims to analyze students' misconceptions on cell material as the smallest unit of life and sources of misconceptions. This research is useful for teachers to be able to evaluate learning strategies, methods and models.

METHODS

Research Design

This type of research was descriptive quantitative. The research subjects were 35 students. The FTDT was used to determine the level of students' understanding of a concept. The four-level diagnostic test was prepared based on indicators from the biology syllabus for class XI IPA SMA Negeri 1 Pagaran. Interviews were conducted with students to find out more deeply about the misconceptions on the items and the source of the misconceptions.

Population and Samples

The population in this study were all students of class XI IPA SMA Negeri 1 Pagaran, which consisted of three classes, namely class XI IPA-1 as many as 36 people, XI IPA-2 as many as 36 people, and XI IPA-3 as many as 35 people, a total of 107 people. The sample in this study were 35 people who were taken using simple random sampling technique.

Instrument

The test instrument used in this study was the Four-tier Diagnostic Test of the cell material as the smallest unit of life, as many as 18 items were given to students using google form. The Four-tier Diagnostic Test was prepared based on indicators from the biology syllabus of class XI IPA SMA Negeri 1 Pagaran, which is presented in Table 1.

Tabel 1.
The Four-tier Diagnostic Test of the cell material as the smallest unit of life.

	Basic Competency	Indicator of Basic Competency	Question Number
3.1.	Explain chemical components constituent cells, structure, function and that process takes place in	1. Explain Component chemical constituents cell 2. Explain structure and function of the cell 3. Explain cell activity as a unit structural and functional living things	1,8 2,3,4,5,7,9,17 10, 11

	Basic Competency	Indicator of Basic Competency	Question Number
	cells as units the smallest of life		
3.2.	Analyze various bioprocesses in that cell covers mechanism membrane transport reproduction and protein synthesis	1. Analyze mechanism transport membrane	6,12, 13
		2. Analyze protein synthesis to compose morphological properties and cell physiology	14, 18
		3. Analyze cell reproduction as an activity to form body morphology and reproduce body	15, 16

Procedure

The research begins with determining the school, population and sample. Then, a preliminary research was conducted to map the subjects with the highest indication of misconceptions. After that, the development of a test instrument in the form of a four-level diagnostic test was carried out. Internal and external validation is carried out on this test instrument. Items that meet the requirements are used to determine students who experience misconceptions, do not understand concepts and understand concepts. Furthermore, interviews were conducted with students who experienced misconceptions to find out the source of the misconceptions.

Data Analysis Techniques

The data analysis techniques used in this study were (1) measuring student learning outcomes by calculating cognitive scores (levels 1 and 3) according to the scoring guidelines based on Fariyani et.al (2015); (2) Calculating the percentage of completeness of learning outcomes in accordance with the specified Minimum Completeness Criteria , namely 70; (3) Grouping the student test results into several categories, namely Concept Understanding, Not Understanding Concepts, and Misconceptions based on Fariyani et.al (2015); (4) Calculating the percentage of students who understand concepts, do not understand concepts, and misconceptions; (5) Determine the level of misconception categories based on Istighfarin (2015); (6) Determining the value of CDQ (Confidence Discrimination Quotient) to find out whether students can distinguish what they understand and what they don't understand based on Caleon& Subramaniam (2010).

RESULT AND DISCUSSION

Student learning outcomes after giving questions on the four levels of cell material as the smallest unit of life to 35 students obtained the highest score of 69.4 and the lowest score of 11.1. The learning outcomes indicated that all students did not reach the minimum completeness criteria.

The data obtained from the results of FTDT are interpreted to be grouped into the criteria for misconception, understanding, and not understanding on each item. In Figure 1, the average percentage of students who experience misconceptions, do not understand concepts and understand concepts is presented in Figure 1. The percentage level of students' understanding of each indicator can be seen in Table 2.The data obtained from the results of FTDT are interpreted to be grouped into the criteria for misconception, understanding, and not understanding on each item. In Figure 1, the average percentage of students who experience misconceptions, do not understand concepts and understand concepts is presented in Figure 1. The percentage level of students' understanding of each indicator can be seen in Table 2.
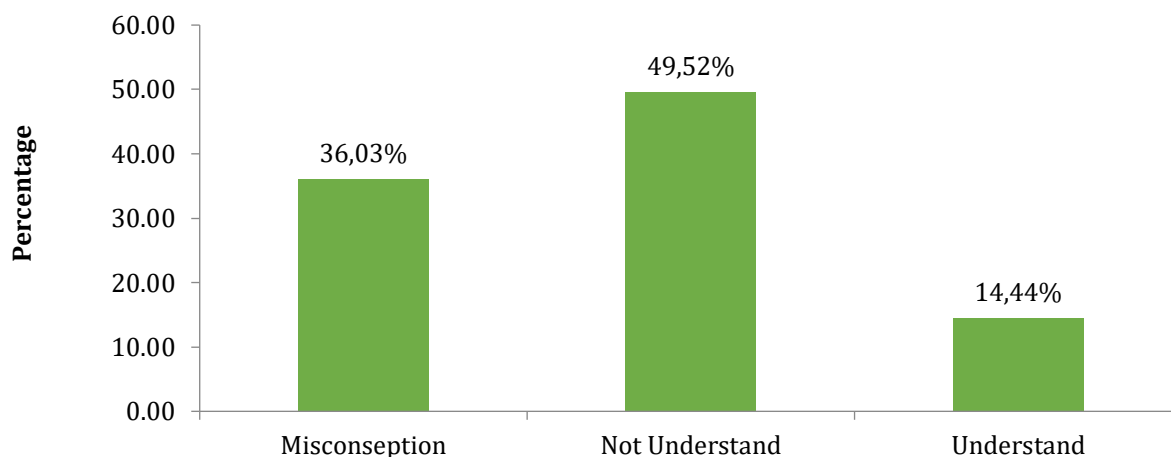

Figure 1. The average percentage of misconceptions, do not understand and understand

Based on the presentation in Table 2, it shows that misconceptions occur in all indicators of cell material. The highest misconception occurred in the indicator analyzing the membrane transport mechanism and the lowest in the indicator explaining the chemical components of the cell. In the indicator explaining the chemical components of a cell, there are two forms of misconception, first, students believe the wrong reason for the concept of cells that cells are the smallest unit of life composed of organic and inorganic compounds. According to Hasibuan & Harahap (2016), misconceptions often occur in subject matter related to cells. Based on the results of the interview, it is known that the concept of the cell is abstract so it is difficult to understand. The application of technology in learning may make it easier for students to understand abstract material. Second, students can answer correctly that hemoglobin is an example of a transport protein but are convinced of the wrong reasons. This form of misconception shows that students can explain a concept correctly but do not know the reason for the concept (Sulistiwarni, 2018). However, another possibility can occur where students do not actually know the answer and just guess. Based on the results of the interviews, the source of students' misconceptions on this indicator was textbooks. Misconceptions in biology textbooks can include incorrect information, and are often slow to find and correct (Storey, 1991).

Table 2.
Percentage of FTDT Interpretation on Each Indicator

No	Indicator	Percentage (%)*		
		1	2	3
1	Explain Component chemical constituents cell.	28.57	38.57	32.86
2	Explain structure and function of the cell.	32.24	53.06	14.69
3	Explain cell activity as a unit structural and functional living things.	34.29	51.43	14.29
4	Analyze mechanism transport membrane.	48.57	47.62	3.81
5	Analyze protein synthesis to compose morphological properties and cell physiology.	45.71	50.00	4.29
6	Analyze cell reproduction as an activity to form body morphology and reproduce body.	30.00	48.57	21.43

*1 = Misconception; 2 = Not Understand; 3 = Understand

Misconceptions that occur in the indicator explain the structure and function of the cell parts, namely first, students do not know the exact structure of the cell membrane. Based on the results of the interviews, students believed that the cell membrane was only composed of glucose and protein. This is supported by research by Emriyuni et al. (2018) found that generally students answered that carbohydrates do not include cell membrane components. Second, students can recognize the differences in the structure of chloroplasts and mitochondria but do not know the reasons that distinguish the two organelles. Misconceptions on the reasons for this answer result from incomplete or wrong reasoning. Based on the results of the interviews, the source of the misconception on this indicator was the internet where students look for answers on blogspot. Students work on assignments using the copy-paste method without worrying about the reliability of the source. This finding was supported by the results of research by Fadillah (2018) which states that the internet was a factor causing misconceptions. Sesen & Ince (2010) explain that most students accept that what is found on the website is true, without considering the source or purpose of the information. This proves that students do not know how to use the internet, especially when looking for information on the website.

Misconceptions in the indicator explain the activity of the cell as a structural and functional unit of living things, namely the error in understanding the characteristics of the cell membrane where students answer that the cell membrane is composed of hydrophilic phospholipids. This may occur because students do not know the concept of cell membrane structure at all.

Misconceptions on indicators analyze membrane transport mechanisms, which are important concepts of diffusion and osmosis. Students know that osmosis is the transfer of water from a high concentration to a low concentration but do not know the meaning of the concentration of a solution so that they cannot determine which part of the water concentration is higher and which water concentration is lower. The source of the misconception on this indicator is friends. According to Suparno (2013), students are very happy to learn from group friends in doing questions and doing practical activities so that they are easily influenced by what their friends or gangs express, think, and make.

The misconception on the indicators of analyzing protein synthesis is that students are able to answer correctly that the translation process is shown by the translation of bases in dRNA by tRNA, but there are errors in determining the location of the translation. This event shows that students have not been able to understand the reason for the answer because their understanding is not complete. Tanziyah (2015) emphasizes that incomplete understanding is a factor causing misconceptions. The source of the misconceptions on this indicator

is books. Nusantari (2011) found several errors in textbooks that caused misconceptions such as the use of analogies and inappropriate terms and errors in choosing language or words.

Misconceptions also occur in indicators of analyzing cell reproduction. Students are unable to distinguish between mitosis and meiosis and the phases in cell division. The student chooses the answer that mitotic division produces daughter cells with half the number of chromosomes from the parent. In general, students can answer correctly on the first level but answer wrong at the third level. Suparno (2013) states that incomplete reasons can be caused because the information obtained is incomplete, resulting in errors in drawing conclusions and causing misconceptions. The source of the misconceptions on this indicator is textbooks. Nusantari (2011) found misconceptions in biology books about the relationship between mitotic division and meiosis with inheritance.

CDQ scores can reveal the correctness of student responses and the level of student confidence in these responses. Positive CDQ indicates that students can discern correct information about concepts, have awareness of knowledge, and negative CDQ indicates that they cannot differentiate between correct information and incorrect information (Bozdağ & Ok, 2019). The results of the CDQ analysis are presented in Table 3.

Table 3.
Recapitulation of CDQ Analysis Results

CDQ	Question Number		
	Answer	Reason	Both
CDQ<0	4,10	4,7,10,13,14,16,18	4,10,12,16
Total	2	7	4

The negative CDQ value in questions number 4 and 12 indicates that students have not been able to understand the concept of the structure and function of the cell membrane, as evidenced by the findings of high category misconceptions on these indicators.

The low CDQ value is because the CFW variable has a greater value than the CFC variable (Bozdağ & Ok, 2019). This shows that students tend not to be able to distinguish between what they know and what they don't know. In addition, students' belief in the wrong answer shows that they hold the wrong concept about the material.

CONCLUSION

Based on the results of the study, it is known that misconceptions occur in all indicators of learning cell material where the highest misconceptions occur in indicators of analyzing membrane transport mechanisms, and the lowest misconceptions occur in indicators of explaining the chemical components of cells. Based on the results of the interviews , the sources of the misconception of cell material as the smallest unit of life were textbooks, friends and the internet. To reduce the risk of misconceptions in students, especially in abstract material, it is necessary to learn strategies and methods with the help of technology and study books that will be used as a source of student learning.

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