STUDENTS' MISCONCEPTIONS PROFILE IN CELL BIOPROCESS USING THREE-TIER DIAGNOSTIC TEST

Profil Miskonsepsi Peserta Didik pada Materi Bioproses Sel menggunakan Instrumen Tes Diagnostik Three-Tier

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Abstract

Lack of conceptual comprehension can lead students to form a wrong concept. Students' conceptual comprehension that is different from the actual concept is called a misconception. Biological topic that is prone to misconception is cell bioprocess because the topic is abstract and complete. This research aims to describe the profile of students' misconceptions using the three-tier diagnostic test, to describe the factors that cause misconceptions, and to offer solutions that overcome students' misconceptions in cell bioprocess topic. The data collection methods were carried out by providing a three-tier diagnostic test through google form and interviewing through google meet and social media. The research subjects were 60 students of the 11th grade MIPA in SMA Negeri 1 Kamal. The data of diagnostic test were processed and grouped according to the category of students' conceptual comprehension, besides the interviews data were analyzed by generalizations based on interviews' answers. The results showed that 76% misconception occurred in cell bioprocess with 79.40% misconception in membrane transport, 74.30% misconception in protein synthesis, and 71.80% misconception in cell reproduction. Factors that cause misconceptions are students' low mastery of the concepts, the use of complicated terms and incomplete information in textbooks, also the lack of interaction between teachers and students. Students' misconceptions can be reduced through the application of interactive models or media that assist in constructing conceptual comprehension correctly. Further studies of the development and implementation of digital-based learning media in cell bioprocess topic including membrane transport, cell reproduction, and protein synthesis sub-topic should be done near the future to reduce students' misconceptions.

Keywords: misconception, cell bioprocess, three-tier diagnostic test

Abstrak

Kurangnya pemahaman konsep dapat menggiring peserta didik membentuk konsep yang keliru. Pemahaman konsep peserta didik yang berbeda dengan konsep sebenarnya disebut sebagai miskonsepsi. Materi biologi yang rawan terjadi miskonsepsi adalah bioproses sel karena materinya bersifat abstrak dan kompleks. Penelitian ini bertujuan untuk mendeskripsikan profil miskonsepsi peserta didik menggunakan instrumen diagnostik three-tier, mendeskripsikan faktor penyebab miskonsepsi, serta menawarkan solusi yang dapat mengatasi miskonsepsi peserta didik pada materi bioproses sel. Metode pengumpulan data dilakukan dengan memberikan instrumen diagnostik three-tier melalui google form dan wawancara melalui google meet dan media sosial. Subjek penelitian ini yaitu 60 peserta didik kelas XI MIPA di SMA Negeri 1 Kamal. Data tes diagnostik diolah dan dikelompokkan sesuai kategori pemahaman konseptual peserta didik sedangkan data wawancara dianalisis berdasarkan generalisasi jawaban peserta didik. Hasil penelitian mengungkapkan bahwa peserta didik mengalami miskonsepsi pada materi bioproses sel sebesar 76% dengan persentase miskonsepsi pada sub materi transpor membran sebesar 79.40%, sintesis protein sebesar 74.30%, dan reproduksi sel sebesar 71.80%. Faktor penyebab terjadinya miskonsepsi yaitu rendahnya penguasaan konsep peserta didik, adanya penggunaan istilah yang rumit dan informasi yang kurang lengkap pada buku, serta minimnya interaksi antara guru dan peserta didik. Miskonsepsi peserta didik dapat direduksi melalui penerapan model atau media interaktif untuk membantu dalam mengkonstruk pemahaman konsep yang benar. Kajian lebih lanjut tentang pengembangan dan implementasi media pembelajaran berbasis digital pada materi bioproses sel meliputi sub materi transpor membran, reproduksi sel, dan sintesis protein harus dilakukan dalam waktu dekat untuk mengurangi miskonsepsi peserta didik.

Kata Kunci: *miskonsepsi, bioproses sel, tes diagnostik three-tier*

INTRODUCTION

The concept is a collection of stimuli in the form of ideas, objects, or events with the same characteristics (Ibrahim, 2012). The concept is also defined as the basis of thinking that can be used to solve a problem (Hasibuan and Harahap, 2016). Conceptualization or concept formation is an important factor that supports learning activities because students need a concept to comprehend and correlate new concept to be accepted. The data results of the PISA test in 2018 showed that Indonesia ranked 71st out of 79 countries in science subjects with an average score of 396 (OECD, 2019). This data indicates that the mastery of the students' concept in Indonesia is still low so it affects the high-order thinking skills. Lack of conceptual comprehension also affect the effectiveness of the learning process and lead students to form the wrong concept. The misinterpretation of the concept due to its incompatibility with the concept of experts is called a misconception (Kirbulut and Geban, 2014).

Misconception can be defined as students' conceptual comprehension that is different from the actual concept so it is considered an inappropriate comprehension of an idea, object, and event constructed based on one's experience. Misconception occurs due to various factors, namely the condition of students, teachers/educators, textbooks, context, and teaching methods (Suparno, 2013).

Research by Queloz et al. (2017) revealed that there are still many misconceptions on various biological topics, such as evolution, metabolism, cell biology, and genetics. The topic of cell biology includes cell structure, function, and bioprocess is an essential concept that must be understood by students because it becomes a prerequisite for studying the topics of structure and physiology, genetics, and metabolism of living things. Misconception experienced by students on the concept of cell bioprocess occurs because a cell is the smallest unit of the constituent living things' body so the various processes that occur in cells are abstract to be studied. Also, the cell bioprocess topic is very complete and also complicated because it includes membrane transport, protein synthesis, and cell reproduction with different mechanisms' principles and can't be seen directly. This is supported by the research of Suwono et al. (2019) which showed the occurrence of misconception in cell biological topic is 28.4% which includes cell structure and function, the basic component of the cell, substance transportation through a membrane, and cell division. Besides, other research shows the students'

misconceptions occurs in the concept of membrane transport, including diffusion process, is 36.36% (Tanziyah, 2015) and misconceptions in genetic topic include protein synthesis is 33.46%; RNA structures are 36.84%; also cell, chromosome, gene, and DNA are 37.45% (Hidayat and Kasmiruddin, 2020).

Students' misconceptions can be identified using the diagnostic test, one of which is a three-tier test with a multiple-choice form. The three-tier test is a combination of the two-tier diagnostic test (multilevel multiple-choice) and CRI (Certainty of Response Index) developed by Haki Pesman and Ali Eryilmaz. This diagnostic test is composed of three levels, namely the first level (content tier) in the form of question-answer options, the second level (reason tier) in the form of reasonable options for the previous answer, and the third level (confidence tier) in the form of confidence options for the previous answer at the first level and the second level. The three-tier diagnostic test can be used to accurately determine the percentage of students who experience misconception because it provides a level of confidence in the selected answer so the test results obtained are more significant (Gurel et al., 2015).

The existence of technological advances can be used to collect data on students' misconceptions, one of which is by providing diagnostic test in google form that can be accessed anywhere and anytime so it makes easier for students especially in the Covid-19 pandemic conditions.

According to the Indonesian Education Assessment Center in 2019, it was stated that the average percentage of mastery of Biomolecular and Biotechnology topics in Bangkalan Regency was 39.12% (Kementerian Pendidikan dan Kebudayaan, 2019). This percentage is below the predetermined minimum limit of 55%. Therefore, the researcher chose Bangkalan Regency precisely at SMAN 1 Kamal as the research subject because this school is one of the favorite schools. Also, the ease of access in data collection was considered by the researcher to research at SMAN 1 Kamal.

Based on the description, the research was conducted to describe the students' misconceptions profile of 11th grade MIPA in SMAN 1 Kamal, Bangkalan using the three-tier diagnostic test, to describe the factors that cause misconceptions, and to offer solutions that overcome students' misconceptions in cell bioprocess topic.

METHOD

This type of research is descriptive evaluative that conducted to describe students' misconceptions in cell

bioprocess topic using the three-tier diagnostic test. This research was conducted at SMA Negeri 1 Kamal in December 2020 - January 2021 with 60 students of the 11th grade MIPA who had received cell bioprocess topic as a research subject. This research was composed of three stages, namely preparation, implementation, and completion.

The preparation stage includes the process of preparing a three-tier diagnostic test in form of google form and interview instrument. The diagnostic test consists of 20 questions arranged in the form of multiple-choice and true-false, while the interview instrument for students consists of 16 questions that contain the misconceptions' factor aspects and interview instrument for biology teacher consist of 5 questions that contain topic and learning aspects. The validity of the diagnostic instrument test that has been developed will be tested using the following formula.

$$\% \ Appropriateness = \frac{\sum Suitable \ answers \ from \ all \ reviewers}{\sum Maximum \ answers \ from \ all \ reviewers} \ x \ 100\%$$

The validity results of the diagnostic instrument test can be interpreted in table 1.

Table 1. Validation Score Category

Percentage (%)	Validity Category
0,00 – 24,99	Highly invalid
25,00 – 43,99	Invalid
44,00 – 62,74	Moderate valid
62,75 – 81,49	Valid
81,50 – 100,00	Very valid

Source: Riduwan (2012)

The implementation stage includes the process of retrieving data at SMA Negeri 1 Kamal was conducted by providing a google forms' link of diagnostic instrument test in the google classroom platform and interviewing three students with the highest misconception and also biology teacher using google meet and social media.

The completion stage includes the data analyzed by generalization to answer the problem formulation. The data of diagnostic test were processed and grouped according to the category of students' conceptual comprehension that can be interpreted through the table 2.

Table 2. Students' Conceptual Comprehension Category

Tier			Category
1	2	3	
correct	correct	sure	comprehend the concept

Tier			Category
1	2	3	
correct	correct	not sure	not comprehend the concept
correct	wrong	sure	positive misconceptions
correct	wrong	not sure	not comprehend the concept
wrong	correct	sure	negative misconceptions
wrong	correct	not sure	not comprehend the concept
wrong	wrong	sure	misconceptions
wrong	wrong	not sure	not comprehend the concept

Source: Arslan et al. (2012)

The percentage for each category of students' conceptual comprehension can be obtained using the following formula.

$$P = \frac{f}{N} \ x \ 100\%$$

Description:

P   = Percentage of conceptual comprehension
F   = Students' number in each category
N   = Total students' number

The percentages' calculation results of students' misconceptions can be interpreted in the table 3.

Table 3. Misconception Criteria

Percentage (%)	Misconception Criteria
0.00 – 30.99	Low
31.00 – 60.99	Moderate
61.00 – 100.00	High

Source: Didik et al. (2020)

The interview activities were conducted by interview guidelines to identify the causes of students' misconceptions. The interviews data were analyzed by generalizations based on interviews' answers.

RESULT AND DISCUSSION

The validity of the three-tier diagnostic test that has been developed was 96.53% and categorized as very valid theoretically. A high percentage of validity indicates the high accuracy of the research results (Muijs, 2012) because the diagnostic test can measure and identify students' misconceptions. The cell bioprocess topic listed in KD 3.2 for senior high school 11th grade

includes three sub-topics namely membrane transport, cell reproduction, and protein synthesis. The research data revealed that students' misconceptions occurred in each sub-topic of cell bioprocess and was presented in the form of the table 4.

Table 4. Recapitulation of Students' Misconceptions in Cell Bioprocess Topic

No	Concept	Misconception (%)
	Membrane Transport	
1	Osmosis event	73.5
2	Diffusion event	70
3	Differences in osmosis and diffusion	93
4	Endocytosis and exocytosis	80
5	Endocytosis event	75
6	Active membrane transport event	85
	Cell Reproduction	
7	Mitosis and meiosis division	75
8	Mitosis divisions' phase	76
9	Meiosis division	70
10	Meiosis divisions' phase	48
11	Differences in mitosis and meiosis division	90
	Protein Synthesis	
12	mRNA function	60
13	Protein synthesis' phase	76
14	Transcription process	77.5
15	Translation process	78
16	Differences in transcription and translation	80

Based on the table 4, it was known that students experience misconception in all concepts of membrane transport, cell reproduction, and protein synthesis. In membrane transport sub-topic, the highest misconception was found in the differences of osmosis and diffusion concept which is 93%. The average of students answered that osmosis and diffusion are active membrane transport that required energy for molecular displacement because they against the direction of the concentration gradient (low to high). The correct concept of osmosis and diffusion are including passive membrane transport that doesn't require energy for molecular movement because it is in the same direction as the concentration gradient (high to low) (Soult, 2021).

The second highest misconception in membrane transport sub-topic was found in the active membrane transport event concept which is 85%. The average of students answered that the potassium ions transport doesn't require energy because it is in the direction of the concentration gradient. The correct concept is that the potassium ions transport occurs against a concentration gradient so it requires energy (Wardhan and Mudgal, 2018).

The third highest misconception in membrane transport sub-topic was found in the endocytosis and exocytosis concepts which are 80%. The average of students answered that the entry and exit of protein through cell membrane occurs because it against the concentration gradient. The correct concept is the entry of protein into the cell through the formation of vesicles from the membrane while the release of protein from the cell through the incorporation of vesicles with the membrane (Campbell et al., 2018).

The next misconception was in the endocytosis event concept which is 75%. The average of students assumed that the phagocytosis process in macrophage cells is due to the special receptors that eat pathogens or damaged cells. The right concept is the phagocytosis process in ingesting large particles by sticking out pseudopodia (Campbell et al., 2018).

In the osmosis event concept, there was found a misconception which is 73.5%. The average of students assumed that osmosis is the active membrane transport so the cell in hypertonic solution causes the occurrence of plasmolysis or crenation event. Students also believe that hypotonic solutions cause cells to be in a normal state. The right concept of osmosis is passive membrane transport because the displacement of water molecules occurs in the same direction as the concentration gradient. This causes the occurrence of plasmolysis or crenation event in the cell if it is in a hypertonic solution whereas if the cell is in a hypotonic solution it cause the occurrence of deplasmolysis or hemolysis event (Soult, 2021).

In the diffusion event concept, there was also a misconception which is 70%. The average of students believes that the transfer of glucose molecules from a high concentration to a low concentration that occurs with the ion pumps is a facilitated diffusion event. The most appropriate concept is that the facilitated diffusion process occurs due to the existence of carrier proteins to move large molecules such as glucose towards the concentration gradient through the membrane (Villaluenga and Barragán, 2015).

In the sub-topic of cell reproduction, the highest misconception was found in the differences of mitosis and meiosis division concept which is 90%. The average of students answered that mitosis aims to reduce the number of chromosomes while meiosis aims to increase

the number of chromosomes. The correct concept is that mitosis division aims to regenerate cells so it is necessary to maintain the number of chromosomes while meiosis aims to form gamete cells so it is necessary to reduce the number of chromosomes (Bavle, 2014; Ohkura, 2015).

The second highest misconception in the cell reproduction sub-topic was found in the mitosis division concept which is 76%. The average of students answered that the metaphase stage is characterized by a chromatic movement towards the opposite pole. The correct concept of the anaphase stage is the chromatic movement towards the opposite pole occurs and if colchicine was added cause inhibition of chromatid separation during mitosis (Saraswati et al., 2017; Campbell et al., 2018).

The third highest misconception in the cell reproduction sub-topic was found in the mitosis and meiosis division concept which are 75%. The average of students assumed that in the event of spermatogenesis, there is mitosis division produces a single diploid daughter cell and meiosis division produces two haploid daughter cells. The concept of mitosis division is correct, but the correct concept of meiosis division is to produce four haploid daughter cells (Bavle, 2014).

The next misconception was in the meiosis division concept which is 70%. The average of students assumed that the reduction in the number of chromosomes occurs through mitosis division. The right concept of meiosis division is referred to a reduction division because it aims to reduce the number of chromosomes so it can keep the daughter cell of sexual reproduction results to have the same number of chromosomes as the parent cells (Ohkura, 2015).

In the meiosis division stages concept, there was also a misconception which is 48%. The average of students believes that the homologous chromosomes and single chromosome lined up in the equatorial field are included in anaphase 1 and anaphase II stages. The most appropriate concept is the anaphase I and anaphase II stages are characterized by the movement of homologous chromosomes and single chromosomes towards the opposite pole (Campbell et al., 2018).

In protein synthesis sub-topic, the highest misconception was found in the differences of transcription and translation concept which is 80%. The average of students answered that the transcription process occurs in ribosomes with the help of the aminoacyl tRNA synthetases enzyme. The correct concept is that the transcription process occurs in the nucleus and is assisted by the RNA Polymerase enzyme to form mRNA, tRNA, and rRNA (Clancy and Brown, 2008; Campbell et al., 2018).

The second highest misconception in protein synthesis sub-topic was found in the translation process concept which is 78%. The average of students answered that the elongation stage is characterized by the appearance of stop codon as a signal to stop the translation process. The correct concept is that in the elongation stage there is an extension due to the addition of new amino acids into the previous amino acids by involving several proteins which are referred to as elongation factors (Campbell et al., 2018).

The third highest misconception in protein synthesis sub-topic was found in the transcription process concept which is 77.5%. The average of students assumed that nitrogen adenine base (A) binds to thymine (T) in the RNA chain. The right concept is nitrogen adenine base (A) binds to uracil (U) in the RNA chain and always transcribed in the 5' to 3' direction (Rachmadiarti et al., 2007).

The next misconception was in the protein synthesis stage concept which is 76%. The average of students assumed that the translation process is the translation of DNA genetic code into rRNA that serves to bring codon to the ribosome. The right concept of translation is the translation of codons that are carried by mRNA as a printout during the transcription process (Campbell et al., 2018). The release of mRNA from the nucleus indicates the ending of the transcription process.

In the mRNA function concept, there was also a misconception which is 60%. The average of students believes that mRNA serves to string amino acids into polypeptides and then form proteins. The most appropriate concept of mRNA function is to carry codon containing genetic information from DNA (Clancy and Brown, 2008).

Based on the data research, it was known that the highest percentage of misconception is in the membrane transport sub-topic which is 79.40%. Then the second highest misconception was found in protein synthesis sub-topic which is 74.30% and the lowest misconception was found in cell reproduction sub-topic which is 71.80%. The percentage of misconception in each sub-topic of cell bioprocess can be interpreted in the following diagram.
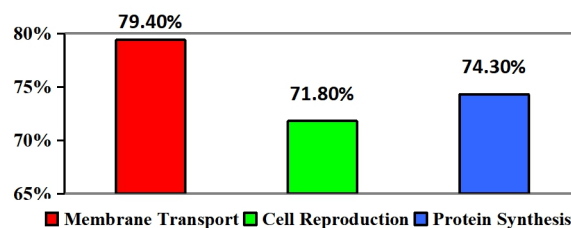

Figure 1. Students' Misconceptions Diagram in Cell Bioprocess Topic

The research data also mapped the students' conceptual comprehension in cell bioprocess topic including comprehend the concept, misconception, and not comprehend the concept as presented in the following diagram.
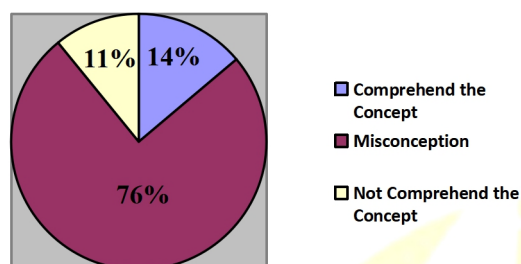

Figure 2. Students' Conceptual Comprehension Diagram in Cell Bioprocess Topic

The diagram shows that the percentage of students' misconceptions in cell bioprocess topic was much higher (76%) than students who comprehend and not comprehend the concept with percentages are 14% and 11%. The high percentage of students' misconceptions occur due to several factors including the condition of students, teachers/educators, textbooks, context, and teaching methods (Suparno, 2013).

Based on the results of interviews conducted on teachers and students, it can be known the factors that cause misconceptions in cell bioprocess topic. The factors that cause misconceptions come from the condition of students who find them difficult to study cell bioprocess topic and assume that the topic is abstract, complete, and complicated, supported by a very small size of the cell that can't be seen without a microscope. The low mastery of the concept and also the incomplete and limited students' comprehension can lead to misconception because students build their comprehension with a different concept (Ibrahim, 2012).

The next contributing factor to misconception was textbooks. Textbooks that are used by students are biology books BSE of 11th grade. The use of complex terms supported by some incomplete information in the book causes students to tend to get concepts from the internet with an unknown source that isn't known the truth of the concept. This is in line with the statement of Rahmadani et al. (2017) that the use of difficult language books can lead students to cause misconceptions.

The last contributing factor to misconception was teaching methods. The teacher applies the assignment method with digital literacy and simple practicum. During the Covid-19 pandemic, the practicum only conducted on the topic of osmosis and diffusion due to the limited tools and materials used. This assignment method was considered less effective because it isn't accompanied by discussions to further discuss the truth of the concept. This method shows the lack of interaction between teachers and students so it can cause misconceptions (Suparno, 2013).

Students' misconceptions in cell bioprocess topic can be reduced through the application of models or interactive media such as inquiry, cooperative, discussion, or the use of animated video so students can build the right conceptual comprehension through a learning experience. This is supported by Putri and Harahaps' research (2016) which shows that the application of interactive multimedia with the help of peer tutors can reduce misconceptions in photosynthesis topic. Other research also shows that misconception can be reduced through the application of an open inquiry model (Muallifah et al., 2017).

CONCLUSION

Based on the results of the research, it was found 76% misconception in cell bioprocess topic with percentage of misconception in membrane transport, protein synthesis, and cell reproduction were 79.40%, 74.30%, and 71.80% respectively. Factors that cause misconceptions are students' low mastery of the concepts, the use of complicated terms and incomplete information in the textbooks, and the lack of interaction between teachers and students. Students' misconceptions can be reduced through the application of interactive models or media that assist in constructing the conceptual comprehension correctly.

SUGGESTION

Further studies of the development and implementation of digital-based learning media in cell bioprocess topic including membrane transport, cell reproduction, and protein synthesis sub-topic should be done near the future to reduce students' misconceptions.

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