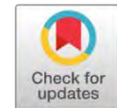


## Research Article

# The mapping of science teacher candidate's prior knowledge in cellular respiration topic



Safira Permata Dewi <sup>a,1,\*</sup>, Djunaidah Zen <sup>a,2</sup>, Maefa Eka Haryani <sup>b,3</sup>

<sup>a</sup> Department of Biology Education, Faculty of Teacher Training and Education, Universitas Sriwijaya, Jalan Raya Palembang - Prabumulih KM. 32 Ogan Ilir, South Sumatera 30662, Indonesia

<sup>b</sup> Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Sriwijaya, Jalan Raya Palembang - Prabumulih KM. 32 Ogan Ilir, South Sumatera 30662, Indonesia

<sup>1</sup>saphire2687@gmail.com \*, <sup>2</sup>djunaidah\_zen@fkip.unsri.ac.id, <sup>3</sup>meafachan@yahoo.com

\* Corresponding author

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### ABSTRACT

The proper learning strategy, mainly in cellular respiration topic, can be determined as mapping teacher candidate's prior knowledge was done. This study aimed to get the profile of prior knowledge of teacher candidates in cellular respiration topic. This survey research used four-tier diagnostic test as data collection instrument. The number of samples was 183 of teacher candidates from three study programs in Faculty of Teacher Training and Education, Universitas Sriwijaya. The data was analyzed using percentage. The results showed that the best understanding of the concept was in the utilization of carbohydrates, proteins, and fats during cellular respiration process. The highest misconception tended to occur in general concept of cellular respiration. Thus, the studies which emphasize the undergirding reasons of the high misconception occurred.



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## INTRODUCTION

Biology is one of the fields of science taught at the junior secondary level. Difficulties faced by science teachers are caused, by the large number of laboratory activities to be carried out, the insufficient time allocation with the number of materials that must be delivered and the severity of the demands of the science curriculum (Kadbey, Dickson, & McMinn, 2015). Ideally, learning biology and other fields are taught in an integrated manner so that it shows synchronization of a material from various sides, but in practice integrated science learning is still taught separately. To overcome this difficulty, the Biology, Chemistry and Physics Education Study Program facilitates by adding General Biology courses for students in the Chemistry and Physics Education Study program. In this general Biology lecture, Chemistry and Physics Education Department students are taught basic biological concepts to equip students as natural science teacher candidates. One of the concepts taught in this lecture is the concept of cellular respiration.

Based on observations made in the previous academic year, it is known that the concept of cellular respiration is one of the concepts that are difficult for students to understand as science teacher candidates.

This is caused by the very abstract characteristics of the material and the process cannot be observed directly. In addition, there is not enough time available to teach a large number of concepts. This is also explained by Cimer (2012), that limited time allocation is one of the reasons biology learning is difficult for students to understand. These time constraints can be overcome by choosing learning strategies, models, media and even concepts that must be focused in the learning process. Rice (2013) further explained that cellular respiration material is a complex material and the learning used so far is less interactive and the learning media used by teachers do not support the formation of student concepts.

Determination of strategies, models, and suitable media can be done with the help of prior knowledge analysis conducted by the teacher before the learning process begins. This prior knowledge test can provide information about the weaknesses and strengths that are owned by students so that the teacher gets an overview of the mapping of students' abilities, including information on the tendency of misconceptions, lack of knowledge and the extent of understanding students' concepts. The results of research that have been done show that there is a positive relationship between prior knowledge tests conducted before learning with the results of student achievement (Tan Geok Shim, Shakawi, & Azizan, 2017). Prior knowledge tests can be done in various ways and have advantages and disadvantages of each (Gurel, Eryilmaz, & McDermott, 2015). One form of test that can be used is the four-tier test. Many studies have been conducted to determine the prior knowledge of students with other forms of tests, but there are no studies that use four-tier tests in biology.

Research on the use of multiple-tiered tests has been carried out to study prior knowledge of students, but so far no research has been conducted to examine prior knowledge of students using four-tier test instruments (Gurel, Eryilmaz, & McDermott, 2017). This is due to the amount of time used to apply this instrument to students (Gurel et al., 2015). However, this problem can be overcome by utilizing online media with the help of Google form in implementing the instrument. Online tests can minimize implementation time and the costs involved, which are more effective and efficient (Alruwais, Wills, & Wald, 2018). The results of research conducted by Mondal, Mondal, Ghosal, & Mondal (2018) also shows that the instruments given using Google form are simpler and easier to use because students use their own android devices. Therefore, researchers are interested in using the four-tier test instrument through online media by using the Google form to find out the prior knowledge of science teacher candidates on cellular respiration material. This study aimed to get the profile of prior knowledge of teacher candidates in cellular respiration topic.

This study was conducted to obtain an overview of prior knowledge of science teacher candidates on the concept of cellular respiration using a four-tier test. The results of this study are expected to help lecturers to determine learning strategies, media, and focus concepts that will be emphasized so as to minimize the possibility of misconceptions on the science teacher candidates after the learning process is carried out.

## METHOD

### Research subject

This research is a survey research to find out prior knowledge of science teacher candidates on cellular respiration material before learning about the concept through online by using Google form. The subject in this study were science teacher candidates and currently undergoing General Biology lectures ( $n = 183$ ), who came from biology, chemistry, and physics education majors. In this study, no special treatment was given because it only wanted to get a prior knowledge of the science teacher candidates.

### Research instrument

The prior knowledge picture of a science teacher candidate was taken using four-tier multiple choice test problems on the concept of cellular respiration. The number of questions used is 20 questions that have been developed based on material analysis, literature analysis of concepts, and the needs of the desired learning objectives. The development of this instrument was only carried out at the first and third levels, whereas for the second and fourth stages there was no specific development because these two levels only asked the level of confidence of the sciences teacher candidates when answering the questions given, which were "sure" and "not sure". Questions at the first and third levels are multiple choice questions with two alternative answers for the second level questions and four alternative answers for questions at the third level. The development of the first level questions is preceded by a linear study related to similar research, while the development of the third level questions is preceded by observations by giving open-ended questions to science teacher candidates to assist in the preparation of alternative answers. The topic uses this research can be seen in Table 1.

The question instrument to find out the prior knowledge of science teacher candidates on Cellular Respiration material that has been developed is entered into the Google form. In the technical implementation of data retrieval, researchers can provide a direct link obtained from the Google form application to the

research sample. The research sample directly works on the problems given through the android device. After the sample has finished answering the questions, it can be sent directly to the system which is then accepted by the researcher.

**Table 1.** The topic used in the prior knowledge analysis of science teacher candidates on the concept of cellular respiration

No	Topic	Question
1.	Aerobic and anaerobic cellular respiration	1, 2, 3, 11, 12, 13, 15, 17,
2.	Cellular respiration process	4, 5, 6, 7, 10, 14, 16, 18, 19, 20
3.	Carbohydrates, protein and lipid metabolism	8, 9,

### Data analysis

The research results obtained were analysed by grouping the results of these achievements into three categories, understanding the concept; lack of knowledge; and misconceptions (Table 2). This prior knowledge category analysis is carried out for each sample on each item tested.

**Table 2.** Analysis of prior knowledge categories of science teacher candidates on the concept of cellular respiration

First tier	Second tier	Third tier	Fourth tier	Criteria
Correct	Sure	Correct	Sure	SC
Correct	Sure	Correct	Not sure	LK
Correct	Not sure	Correct	Sure	LK
Correct	Not sure	Correct	Not sure	LK
Correct	Sure	Wrong	Sure	MSC
Correct	Sure	Wrong	Not sure	LK
Correct	Not sure	Wrong	Sure	MSC
Correct	Not sure	Wrong	Not sure	LK
Wrong	Sure	Correct	Sure	MSC
Wrong	Sure	Correct	Not sure	MSC
Wrong	Not sure	Correct	Sure	LK
Wrong	Not sure	Correct	Not sure	LK
Wrong	Sure	Wrong	Sure	MSC
Wrong	Sure	Wrong	Not sure	MSC
Wrong	Not sure	Wrong	Sure	MSC
Wrong	Not sure	Wrong	Not sure	LK

The results of the prior knowledge grouping analysis are followed by a percentage calculation for the group "sure concept" (Formula 3), "lack of knowledge" (Formula 2), and "misconceptions" (Formula 1).

$$\text{Percentage Misconception} = \frac{\text{Frequency of Misconceptions for each Item}}{\text{Number of sample}} \times 100\% \quad (1)$$

$$\text{Percentage Lack of knowledge} = \frac{\text{Frequency of Lack of knowledge for each Item}}{\text{Number of sample}} \times 100\% \quad (2)$$

$$\text{Percentage Sure concept} = \frac{\text{Frequency of Sure concept for each Item}}{\text{Number of sample}} \times 100\% \quad (3)$$

## RESULTS AND DISCUSSION

Prior knowledge analysis is carried out to determine the extent of understanding of concepts possessed by students at the previous level of education. This can streamline the learning process undertaken so that the utilization of learning time allocation is better. Analysis of prior knowledge can be done in various ways, both by giving questions and giving questionnaires to students before the learning process begins (Hailikari, 2009). Prior knowledge studies conducted have a positive effect on the development of learning design and curriculum planning on learning (Hailikari, Katajavuori, & Lindblom-Ylänne, 2008; Yuksel, 2012). Prior knowledge also has a very important role in the formation of individual characteristics and impacts on conceptual change that may occur after the learning process (Lin, Yen, Liang, Chiu, & Guo, 2016). Analysis of prior knowledge through the provision of questions has been done, among others, by providing open-ended questions, image analysis, concept maps, two-tier tests, three-tier tests, and others (Bergan, Galt, Helikar, & Dauer, 2018; Kirbulut & Geban, 2014; Saat et al., 2016).

The topics studied in the prior knowledge analysis of science teacher candidates on cellular respiration material consisted of three topics, aerobic and anaerobic respiration; stages of cellular respiration; and carbohydrate, protein, and lipid metabolism. Each of these topics is a development of a literature study that has been carried out (Ameyaw, 2016; Bergan et al., 2018; Saat et al., 2016). This literature review is the result of

previous research on prior knowledge analysis using other forms of test instruments. It is intended that the instruments used can really provide an overview of the prior knowledge of science teacher candidates on cellular respiration material.

The first topics tested were aerobic and anaerobic respiration. The concepts tested on this topic include the definition of cellular respiration, the difference between aerobic and anaerobic respiration, the amount of ATP produced, and the fermentation process. The results showed that on this topic the tendency of misconception was very high (average = 72.88%). The highest percentage of misconceptions occurred in problem number 1 about the definition of cellular respiration as much as 84.70% (Figure 1). This problem compared to other questions tested shows a very high tendency for misconception. The response of science teacher candidates to question number 1 (Figure 2) shows that the understanding of science teacher candidates about cellular respiration is still very low. Science teacher candidates assume that cellular respiration is highly dependent on the presence of oxygen, whereas anaerobic respiration is a respiration that does not use oxygen at all in the process (Urry et al., 2017). These results contradict the results of research conducted by Saat et al., (2016) which shows that science teacher candidates in Malaysia have understood the basic concepts of cellular respiration.

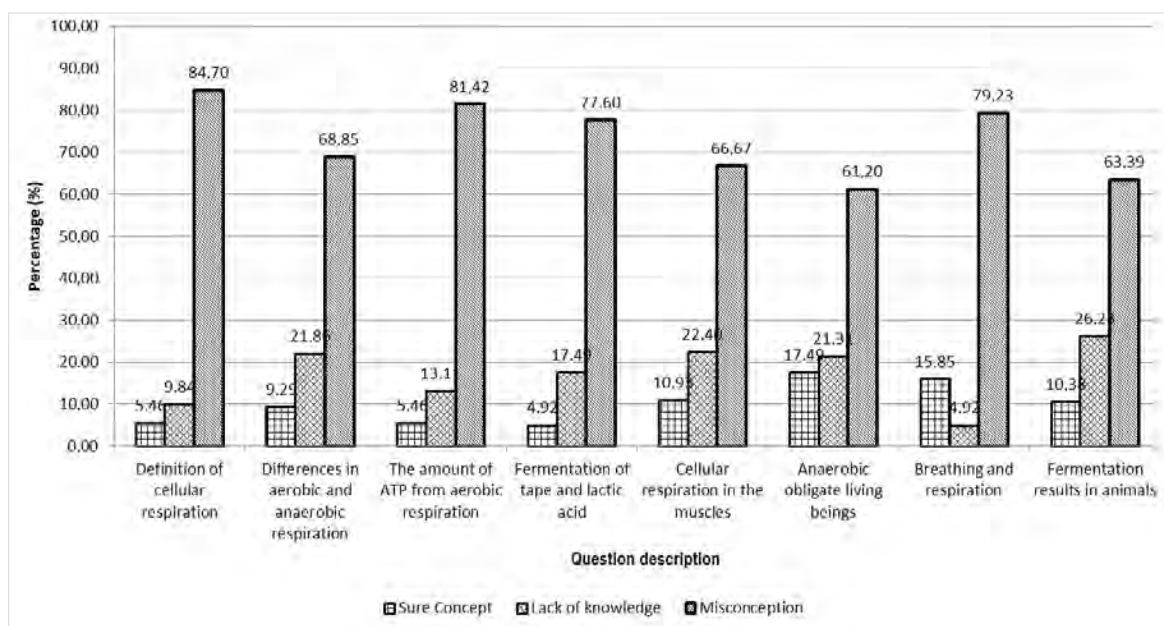


Figure 1. Percentage of prior knowledge achievements of science teacher candidates on the topic of aerobic and anaerobic respiration

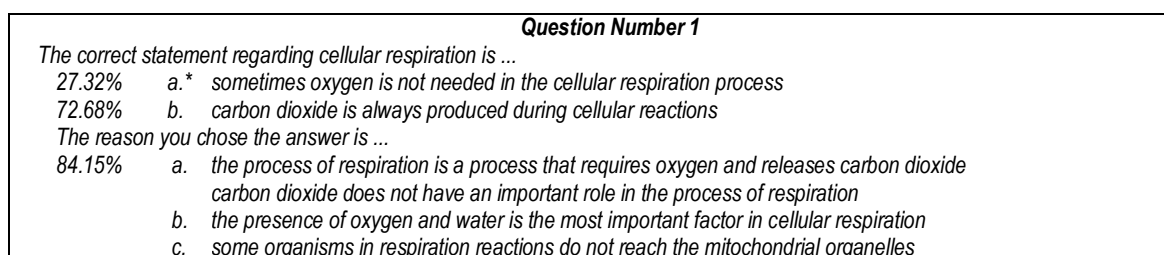


Figure 2. The response of science teacher candidates to question number 1

The response of science teacher candidates to question number 1 (Figure 2) shows that carbon dioxide is a gas produced during the cellular respiration process (72.68%) with the most reason being chosen is the respiration process is a process related to the use of oxygen and carbon dioxide release. This shows that science teacher candidates have a low understanding of the basic concepts of cellular respiration because anaerobic respiration and fermentation do not involve oxygen in the process. Studies on the high school curriculum show that cellular respiration is studied by science teacher candidates in class XII of high school; however, this concept has a close relationship with the concept of respiration system that has been studied by science teacher candidates since they were at the elementary level of education. This incident indicates that the possibility of new concepts about cellular respiration is distorted by old concepts understood by students. This can be seen in the response of the science teacher candidates to question number 15 who asks about

breathing and respiration. Science teacher candidates have an understanding that breathing and respiration are the same thing (66.1%). Confidence in understanding strong concepts can result in students rejecting new knowledge delivered by the teacher (Campbell, 2008; Star, Johnson, Lynch, & Perova, 2009; Yusrizal & Halim, 2017).

The second topic in this study is the metabolism of carbohydrates, proteins and lipids. The results of this study indicate that science teacher candidates already have a good understanding of the concept but are still inadequate. This can be seen from the high tendency of lack of knowledge in questions about this topic (Figure 3). This topic also shows a good understanding of concepts for sub-concepts of the use of protein, carbohydrates, and lipids in the body's metabolism. This good understanding is due to the connection between this topic and the digestive system concept material that has been repeatedly studied by teacher candidates from previous levels of education. This repetitive learning can improve one's understanding of a concept.

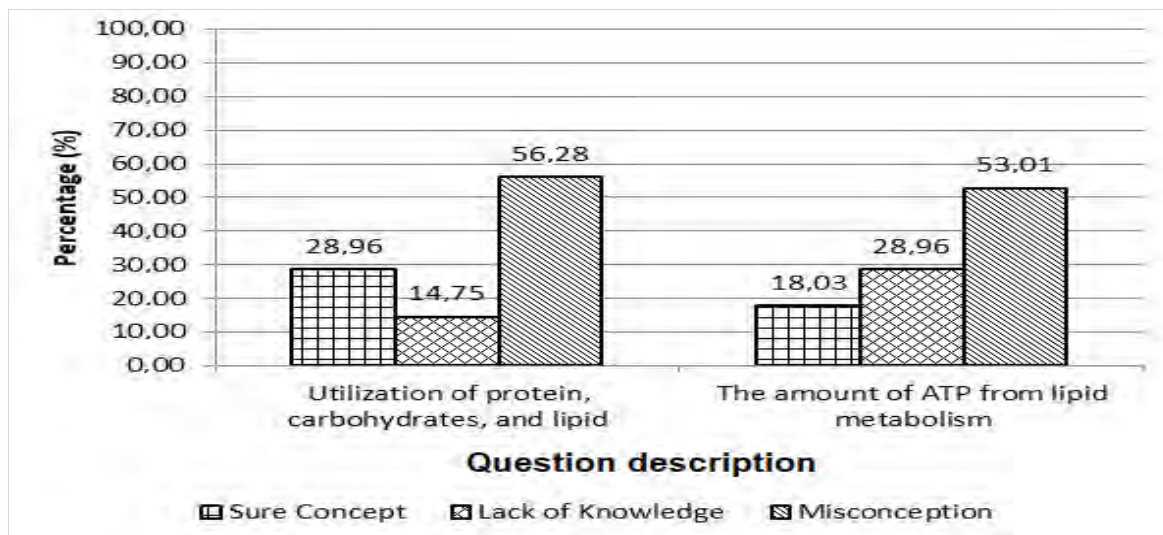


Figure 3. Percentage of prior knowledge achievement of science teacher candidates on the topic of carbohydrates, protein, and lipid.

The tendency of misconception and the lack of knowledge that can be seen from the results of prior knowledge testing of science teacher candidates can be caused by misconceptions that have occurred at the previous educational level. This topic is closely related to the digestive system material that has been studied by science teacher candidates from basic education. Research conducted by (Cardak, 2015) indicates that teachers have a huge opportunity to experience misconceptions on the digestive system material. This misconception has the opportunity to be passed on to students, resulting in students also experiencing misconceptions (Widiyatmoko & Shimizu, 2018).

The third topic tested in this study is the process of cellular respiration. The focus of the study of prior knowledge instruments tested relates to the results of each cellular respiration process. The results showed that understanding the concept of a science teacher candidates on cellular respiration material was better than the other topics tested. The highest understanding of the concept is seen in the concept of the use of NADH and FADH as a result of the cellular respiration process (35.52%) and the main results of the glycolysis process (31.15%) (Figure 4). The results of this study, although they have shown a higher understanding of concepts compared to other topics, still show a tendency towards misconceptions and a lack of understanding of science teacher candidates on cellular respiration material. The results of this study show the same tendency with the results of research conducted by Bergan, et.al. (2018) which examines the understanding of students for each stage of cellular respiration and the understanding of the concept of glycolysis is higher compared to other stages of cellular respiration.

The high tendency of misconception and the low understanding of concepts in prior knowledge of science teacher candidates on cellular respiration material is an event that must be anticipated by the teacher by choosing the right learning strategy (Fisher, Frey, & Lapp, 2012). The formation of the understanding of science teacher candidates is not an instant process. Understanding a person's concept is influenced by many things, namely conceptual understanding and confidence, experiences in daily life, beliefs about a concept that he has, the environment in which he learns, mental development, and contradictions of concepts that are just accepted with old concepts that he has understood (Pekel, 2019; Yusrizal & Halim, 2017). All factors forming this understanding can lead to misconceptions. learning approaches and logical thinking abilities (Gurcay & Gulbas, 2018). The learning process carried out at school also has a role in shaping students' misconceptions,

including terminology that is widely used, textbooks used, and misconceptions originating from teachers and passed on to students (Bayuni, Sopandi, & Sujana, 2018; Erman, 2017; Widiyatmoko & Shimizu, 2018).

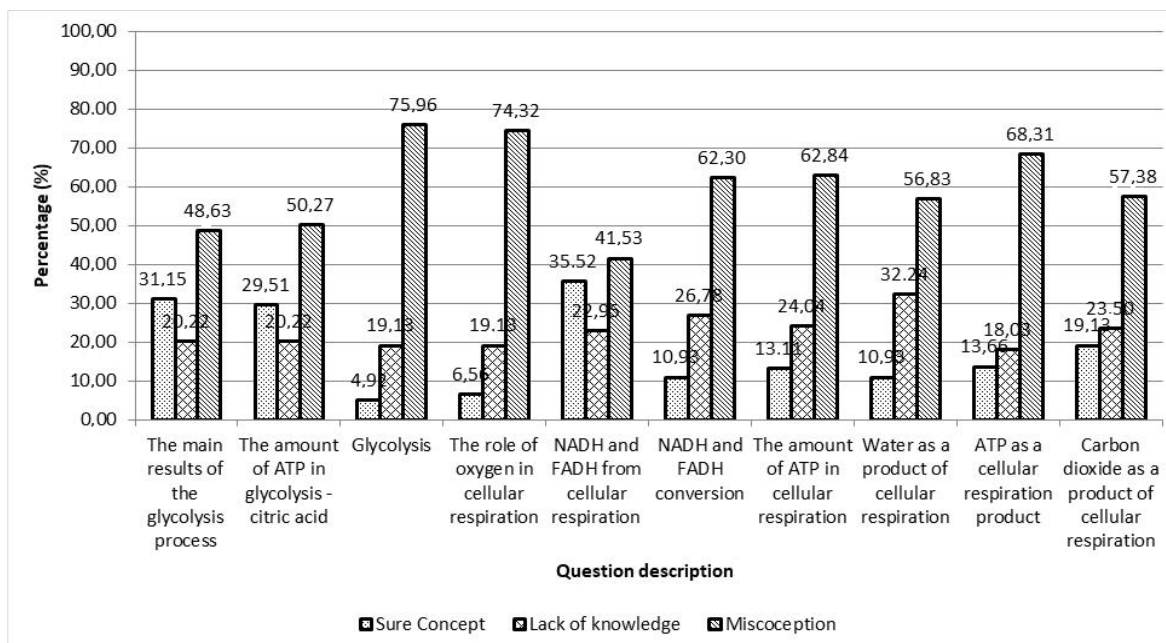


Figure 4. Percentage of prior knowledge achievement of science teacher candidates on the topic of Cellular Respiration Stages

The granting of this four-tier instrument is done through online media with the help of the Google form. The use of Google form media is very effective to help speed up the process of data analysis, the efficiency of the time needed for science teacher candidates in completing the tests provided and to minimize funding budgets when compared with tests conducted in writing. The prior knowledge test using Google form for science teacher candidates on the concept of cellular respiration, researcher enters these questions into the Goggle form to get a link which is then disseminated to the research sample. Samples solve these problems through an android device they have. The process of collecting data is easier to do through this technique, because researchers simply disseminate links from Google forms. After all the questions have been answered, the science teacher candidates send the answers into the system and is immediately collected. Google Forms motivates students' self-regulatory learning (Kato, Kambayashi, & Kodama, 2016). This technique is much easier compared to conventional tests. Alruwais et al., (2018) revealed that the advantages of tests conducted online are the ease of providing feedback to students, making it easier for teachers to administer tests, efficiency of time, reducing costs that might be reviewed, and improving student performance. However, before conducting online tests, it is important to consider the availability of internet network facilities for the sake of the smoothness of the tests conducted.

The results of this study indicate that science teacher candidates still lack knowledge of the basic concepts in cellular respiration material (Figure 5).

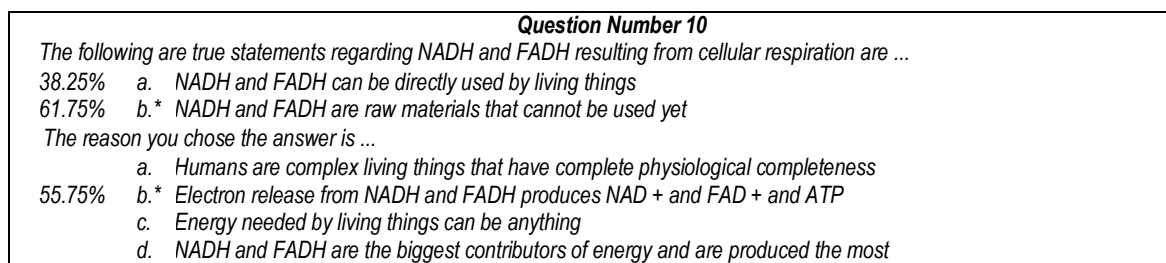


Figure 5. The response of science teacher candidates to question number 1

The tendency of each misconception often occurs on the topic being tested. The results of this study can be used as a main reference for lecturers to emphasize concepts that show high misconceptions, for example on the concepts of aerobic and anaerobic respiration. Animation and video media can be used to help science teacher candidates understand this concept. Using visual aids (e.g., pictures, animation videos, projectors and

films) make the teachers and students had positive perceptions (Islam, Ahmed, Islam, & Shamsuddin, 2014; Shabiralyani, Hasan, Hamad, & Iqbal, 2015). This relates to the very abstract characteristics of cellular respiration material in which a lot of cellular processes cannot be seen by science teacher candidates. Choosing the right media and focusing the concept emphasis is expected to eliminate the tendency to misconceptions of science teacher candidates.

## CONCLUSION

The tendency of the misconception of science teacher candidates on the concept of cellular respiration is still high. The highest percentage occurs in the basic concepts of cellular respiration. The lowest misconception is shown in the concept of cellular respiration stages, because the learning process at the previous level only focuses on cellular respiration stages but does not focus on the basic concepts. It is recommended to conduct knowledge analysis before learning begins to find out the weaknesses and strengths of students so that the learning process is more effective and efficient. Provision of online tests can be done to assist teachers in disseminating questions and analyzing data.

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