

Identification of Students' Misconceptions on the Photosynthetic and Plant Respiration Concepts Using a Two-Tier Diagnostic Test

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Abstract

This study aimed to determine the results of analyzing students' misconceptions of photosynthesis and plant respiration using a two-tier diagnostic test instrument in science class XII. Photosynthetic and respiration are considered abstract concepts and difficult for students to understand, allowing misconceptions to occur. A two-tier diagnostic test is one of the diagnostic tests that can be used to identify students' misconceptions. This study used a descriptive qualitative method, using a two-tier diagnostic test and interviews instrument. The sample of the research was 75 students. The result showed that the students' misconceptions of photosynthetic and respiration concepts scored 27.9% in the low category. In comparison, the cause of students' misconception can be the need for students' ability to understand the detail of the teacher's explanation.

Keyword: Photosynthesis and Plant Respiration Concepts, Students' Misconceptions, Two-Tier Diagnostic Test

INTRODUCTION

One of the goals of education is to facilitate students to understand a concept. Understanding concepts for students is very important because by understanding a concept, students will more readily associate one concept with another. Students' interpretation or understanding of a particular concept is a conception (Ariandini et al, 2013). Interpretation or individual understanding of a concept may vary. Differences in conception are often very different from the concepts put forward by scientists, so they are often referred to as misconceptions (Ariandini et al., 2013).

Misconceptions can prevent students' learning process because they will interfere with the acceptance of new knowledge. After all, misconceptions are resistant to this new knowledge (Fariyani et al., 2015), in line with Rahayu (2011) that misconceptions in students that arise continuously can interfere with the formation of scientific conceptions (Puspitasari, 2017). Therefore, special treatment is needed to diagnose this misconception (Ismi et al., 2020). Some things that cause misconceptions in students include the students themselves, teachers, textbooks, contexts, and learning methods (Puspitasari, 2017).

Based on Ismi et al., (2020) and Suhendi and Ardiansyah (2021), an analysis of misconceptions about photosynthesis learning concepts in senior high school students, the score of misconceptions about photosynthesis material was 25.75% (of 40 students). The misconception with the highest percentage is when photosynthesis occurs at 57.50%.

Photosynthesis and Plant Respiration learning materials are procedural learning materials that have a high level of difficulty because they are not only memorized but must be well understood as a holistic sequence of important events. If it needs to be better understood, the material about photosynthesis and plant respiration is very prone to misunderstandings.

Based on the interview with the Biology subject teachers at one of the senior high schools in Pandeglang, Indonesia, indicated that there were many misconceptions about Photosynthesis and Plant Respiration learning concept, especially in terms of where they occur, wavelengths, and dark reactions in photosystems, the teacher states that students are more many understand the concept that plant respiration only happens at night and only green leaves are capable of photosynthesis. According to Manurung et al. (2017), photosynthesis is a topic that has great difficulty because the discussion on this material is abstract, so it needs to be clarified for students to understand it.

One effort can be made to identify misconceptions in students with a diagnostic test. Ismi et al. (2020) stated that diagnostic tests can be used to determine the strengths and weaknesses of students in learning. A two-tier diagnostic test has been developed and used to determine students' conceptual understanding of several sciences, such as biology, chemistry, and physics (Nahadi and Siswaningsih, 2020).

A two-tier diagnostic test is a diagnostic test with two-level questions. The first level consists of questions with four possible answers, while the second level consists of reasons that refer to the answers to the first level (Habellia et al., 2021). The advantages of using this instrument were: (1) Reducing the probability of guessing; (2) Allows combining several aspects in one phenomenon, where the first tier is the menological domain, while the second tier is the conceptual domain; (3) it is easier to manage and calculate compared to other methods, so it is very useful to use in class (Habelia, et. al., 2021). Therefore, based on the background, the research is carried out to identify and analyze student's misconceptions about photosynthesis and plant respiration concepts using the two-tier diagnostic test instrument at a 12th-grade senior high school in Pandeglang, Indonesia.

METHOD

The research was conducted at 12th grade senior high school students in Pandeglang district, Indonesia. The research subjects consisted of 75 students. Sampling was carried out by random sampling. This is done because this research requires research subjects that are spread out to measure and identify students' misconceptions. Data collection included learning observations, administering a two-tier diagnostic test instrument on Photosynthesis and Plant

Respiration concept, interviewing students who indicated misconceptions, and interviewing biology teachers at one of the senior high schools in Pandeglang, Indonesia.

In this study, several stages were carried out. The first stage was learning observation and interviews with biology teachers at one of the senior high schools in Pandeglang, Indonesia, to identify misconceptions about biological material (photosynthesis and respiration) which occurred; the next stage was distributing questionnaires to students, then the last stage was interviewing participants who indicated misconceptions as the final reinforcement of the results of the questionnaire given.

The instruments used included a two-tier diagnostic test on photosynthesis and plant respiration and structured interviews. Analysis of students' answers on the two-tier diagnostic test instrument used guidelines from Amin and Ikhsan (2021) as shown in Table 1.

Table 1. Combination of Answer Instrument two tier diagnostic test

No.	Category	Answer	
		First level	Second level
1	Cannot be encoded	If both are not filled	
2	Don't understand the concept	False	Not sure
3	Misconception	False	Sure
4	Partially understand	True	Not sure
5	Understand concept	True	Sure

Source: Ismi, et. al., (2020)

Data analysis techniques used the Milles & Huberman method: data collection, data reduction, data presentation, and verification (Sugiyono, 2018). In addition, to determine the categories of misconceptions based on percentages, use the categorization based on Suwarna (2014).

Table 2. Category Miconception

Score (%)	Category
0 – 30	Low
31 – 60	Medium
61 – 100	High

Source: Ismi, et. al., (2020)

Test the validity of the data using a credibility test with triangulation technic by comparing the observed data on photosynthesis learning and interviews with biology teachers, the results of a two-tier diagnostic test on photosynthesis and plant respiration, and the results of interviews with students who indicated misconceptions.

RESULTS AND DISCUSSION

Based on the results of collecting and analyzing data from the two tier diagnostic test instrument in 12th grade class of senior high school on Plant Photosynthesis and Respiration

concept, it showed that the average misconception of students on photosynthesis and plant respiration material was 27.9% (in the low category) as shown in Table 3 .

Table 3. Categories of students' understanding of the concept of photosynthesis and plant respiration

Indicator	Score (%)				
	TD	TP	M	PS	PK
Name processes and compounds Photosynthesis	9.3	18.6	21.3	26.6	24
Explain about photosynthesis occurs in green plants / not	1.3	5.3	29.3	4	60
Mention the place where it happened photosynthesis	5	6.7	8	6.7	73
Mention the time it happened photosynthesis	1.3	4	68	6.6	20
Describe the light reaction process on photosynthesis	2.6	10.6	4	42.6	40
Describe the process of the dark reaction in plant respiration	4	9.3	42.6	21.3	22.6
Describe cyclic electron flow	0	12	18.7	35	34.3
Describe no-cyclic electron flow	0	21.3	32	26.7	20
Average	2.9%	10.9%	27.9%	21.2%	36.7%

Notes: TD (cannot be coded), TP (does not understand the concept), M (misconception), PS (partially understands), PK (understands the concept).

Based on Table 3 it can be implied that the misconception with the high score was in the indicator "mentioning the time of photosynthesis,"; the indicator "explaining the process of dark reactions in plant respiration,"; the indicator "explaining non-cyclic electron flow"; the indicator "explaining related to photosynthesis occurring in green plants/ no"; and the indicator "mentioned the process and compounds of photosynthesis." Subsequently, some indicators become reference points for students' misconceptions about photosynthesis and plant respiration, as shown in Table 4.

Table 4. Description of Students' Misconceptions on Photosystems and Plant Respiration

No.	Scientific Conception	Misconception
1	<p>Compounds needed and produced in Photosynthesis $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 + \text{H}_2\text{O}$</p> <p>1. Chloroplast where photosynthesis occurs, chlorophyll as a supporting substance</p> <p>2. Photosynthesis requires chlorophyll. Chlorophyll a is green, has a group $-\text{CH}_3$ dan and chlorophyll b is yellow to orange, has a group $-\text{CHO}$</p>	<p>1. Chlorophyll is the main compound in photosynthesis</p> <p>2. Photosynthesis requires green plant material or chlorophyll, because photosynthesis can only be performed by green leafy plants</p>

No.	Scientific Conception	Misconception
2	Photosynthesis requires light, there are two reactions, namely the light reaction and the dark reaction	Photosynthesis can only be carried out during the day, when there is sunlight
3	The dark reactions don't need light	The dark reactions always occur at night
4	Cyclic electron flows only use photosystem 1, while non-cyclic electron flows use photosystems 1 and 2	Cyclic electron flow only uses photosystem 1, while noncyclic electron flow uses photosystem 2

The first indicator, "mentioning the time of photosynthesis," asked when photosynthesis occurred, and most of the students answered during the day. This misconception occurs because students think photosynthesis requires sunlight, which can only occur during the day. In contrast, photosynthesis has two reactions, the light reaction and the dark reaction, which can occur during the day and at night. Following the results of research by Nadhifa et al. (2019) that spinach plants given a combination of red and blue Light Emitting Diode (LED) intensity, the higher the intensity given between 68 Lux, the better growth. This is because chlorophyll a and b work together to maximize the photosynthesis process in plants. This statement showed that photosynthesis can occur without sunlight and can occur not only during the day.

The second indicator was "explaining the process of the dark reaction in plant respiration." The question asked how the process of the dark reaction occurred and when it occurred, and most of the students answered that it happened at night. This misconception occurs when students think that a dark reaction means they don't need light, which occurs at night. According to Alamsjah et al (2010), the dark reaction, to be precise, the Calvin cycle, can occur when there is light or no light; the Calvin cycle does not require light. Still, it can be carried out during the day, but generally, during the day, there is a non-cyclic flow where the process collects ATP to then use during the Calvin cycle.

The third indicator was "explaining the flow of non-cyclic electrons." The question asked what photosystem non-cyclic electron flow required, and most students answered photosystem 1. This misconception occurred because students thought photosystem 1 had already occurred in cyclic electron flow and could no longer be used. Alamsjah et al (2010), explained that non-cyclic electron flow uses photosystem 1 and photosystem 2 because chlorophyll a (P700) and chlorophyll b (P680) play a role in non-cyclic electron flow.

The fourth indicator was "explaining whether photosynthesis occurs in green plants or not". The question asked whether photosynthesis was only performed in green plants, and

some students answered correctly. Some answered confidently (misconception category), but some answered unsure (don't understand category). This misconception occurred because students thought that photosynthesis occurs in plants with chlorophyll, and chlorophyll only has green plants because chlorophyll was only green. Rhee (2001) explained that photosynthesis requires a photosystem, where a photosystem is a unit capable of capturing sunlight energy. The photosystem comprises the thylakoid membrane's antenna complexes, proteins, and other organic molecules. The antenna complex acts as an energy collector and contains a collection of pigment molecules, namely chlorophyll a, b, and carotenoid molecules. The difference between chlorophyll a and b is that chlorophyll a is green and has a $-CH_3$ group, which absorbs red and blue-violet light. Meanwhile, chlorophyll b is yellow to orange in color and has a $-CHO$ group, which absorbs blue and orange light. This means that chlorophyll is not only green but also chlorophyll b, which is yellow to orange.

The fifth indicator was "mentioning photosynthetic processes and compounds." In this question, it was asked what compounds were needed, and the compounds produced during the photosynthesis process, and most of the students answered that the main compounds in the photosynthesis process were CO_2 , H_2O , and chlorophyll. Rhee (2001) explains that the simple compounds needed are in the form of organic substances, those were carbon dioxide (CO_2), water (H_2O), and dissolved mineral salts. At the same time, chlorophyll plays a direct role in the light reaction of photosynthesis. Its position in the photosystem is as a reaction center, where the first chemical reaction of photosynthesis that uses light occurs. Chlorophyll is not the main inorganic compound in photosynthesis that makes up glucose. But as a place for reactions to occur and help the process of chemical reactions occurring.

b. Causes of Misconceptions

After obtaining an average result of student misconceptions of 27.9% (low category), further interviews were conducted with biology teachers at one of the senior high schools in Pandeglang and several students who indicated misconceptions related to the causes of misconceptions. After the interview, several points were found to cause misconceptions, including:

1. Student's learning method causes students to get an inappropriate pre-understanding of the concept and lack of proper literature study.
2. Less detailed teacher explanation impact students' further understanding of the concept.

Misconceptions are resistant to change, therefore teachers need to pay attention to these misconceptions so as not to interfere with students' understanding of new material. To overcome the misconceptions about photosynthetic matter (Ismi et al., 2020), we concluded

the solutions included confirmation stage of the teacher on learning material as reinforcement after students did a literature study so that pre-understanding can be fixed. Increase teacher understanding and teacher communication for a detailed explanation of material

CONCLUSION

Based on the results of research, it can be concluded that the Two-Tier Diagnostic Test to 12th grade students at the senior high school level, it was found that the score of misconceptions about photosynthesis and plant respiration was 27.9% and classified as a low misconception category. The results of interviews with students who are classified as having misconceptions also showed that the causes of misconceptions come from the students themselves due to a lack of ability to search appropriate study literature and teacher less detailed explanation of the concept.

SUGGESTIONS

It is hoped that future research will continue regarding research on the causes of students' misconceptions about photosynthesis and plant respiration and be able to figure out the solutions to these problems.

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