Misconceptions on Photosynthesis and Plant Respiration Topics Based on Thinking Styles

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Abstract. Photosynthesis and plant respiration is an important science concept included in the curriculum in many countries, one of which is Indonesia. This topic is repeatedly taught at different age levels from elementary until tertiary education. Students who have misconceptions will assume that the concept they believe is true, but in reality does not conform to the existing scientific concept. Misconceptions will affect students’ knowledge. This knowledge will then be brought continuously to the next level of education and affect the learning achievement. Students’ thinking styles are one of the factors causing misconceptions. This study aimed to identify misconceptions based on the thinking styles of the seventh grade students about photosynthesis and plant respiration. The method used in this study was survey method. The data were collected by employing Matching Familiar Figure Test (MFFT) and Four Tier Test in three schools with high, medium, and low grades. The result showed that the students with impulsive and slowly imprecise thinking style had a higher percentage of misconception than those with reflective and quickly precise thinking styles. This study can be used as a reference to do remediation of misconceptions to improve the quality of learning.

Keywords: misconceptions, thinking styles, MFFT, four tier, photosynthesis and plant respiration

1. Introduction
Photosynthesis is one of the important science concepts incorporated in the educational curriculum applied in many countries including Indonesia. This learning material is repeatedly taught at different ages from elementary until tertiary education [1]. Each student basically has a diverse perception in the understanding of an event. The students' prior knowledge formed on the basis of their own perception can conceivably be appropriate or not if compared to the existing scientific concepts. The students' Initial thinking or prior knowledge acquired before taking formal lessons under the teacher's guidance or obtained from the previous educational level is called preconception [2].

When students are engaged in learning in the classroom, various sets of information and scientific concepts are given by the teacher. Sometimes, the given concepts are the same as or different from the prior knowledge already owned by the students. The difference found between the students' preconception and the existing scientific concepts as well as the difference between the concepts given by the teacher and those received by students become potential to cause misconceptions. Such
misconceptions are those derived from students. The process of teaching and learning activities should not merely be in a way whereby a teacher just explains the material to students, but the teacher should also know the level of students’ understanding of the given concepts including the credibility of the concepts the teacher has. In a classroom, there are a number of students with different ways of thinking and acquiring knowledge, so that when students receive some information from the teacher, they conceivably generate different concepts and misconceptions.

Misconceptions can occur when students independently think and build up their knowledge specifically for abstract things. One of the causes of misconceptions derived from students is their ways or styles of thinking. Viewed from the conceptual tempo or speed, there are a couple of types of thinking styles in learning. They are comprised of reflective thinking, impulsive thinking, quickly precise thinking, and slowly imprecise thinking. According to Kagan [3], those four thinking styles are associated with the conceptual tempo or speed, namely the students’ tendency to act to respond, reflect on, and think about the accuracy of an answer.

One of the factors that influence the achievement of the learning goals is the students’ understanding of the given concepts. Understanding of the given concepts is corresponding to the knowledge formation and students’ achievement. When students experience misconceptions, the misconceptions per se can certainly affect their understanding of concepts. Students experiencing misconceptions will assume that the concepts they believe are true, but in reality are not in accordance with the existing scientific concepts. It is really necessary to identify misconceptions that may arise in students so that further efforts can be made to reduce or even eliminate these misconceptions. If misconceptions are left unchecked, they will naturally affect the students’ knowledge. This kind of knowledge will later on be brought continuously to the next level of education and ultimately end up with affecting students’ learning achievement. The problem in this study refers to how the students’ understanding and misconceptions occur based on their thinking styles on the concept of photosynthesis and plant respiration. This study will investigate the students’ misconceptions (based on their thinking styles) that occur pertinent to photosynthesis and plant respiration materials.

2. Research Method
This study was conducted in three different levels of junior high schools (SMP) in Surakarta, high, medium, and low levels. SMP A referred to a high-category school; SMP B represented a medium-category school; and SMP C was classified as a low-category school. The subjects in this study involved the students of SMP A class 7.1, SMP B class 7C, and SMP C class 7PK.1. This study was conducted in the even semester of 2017/2018 academic year. This study was categorised as a qualitative study with case study method. The data in this study referred to the diagnostic test results of misconceptions and the data of test on students’ thinking styles. The sources of data in this study were the students. The data were collected by tests. Misconception diagnostic test used was four-tier test, and the thinking style test used was Matching Familiar Figure Test (MFFT) developed by [4] referring to the MFFT introduced by Jerome Kagan. The data were analysed by using descriptive qualitative analysis technique.

3. Results and Discussion
Diagnostic identification of misconceptions was undertaken after the types of students' thinking styles were known. First of all, the test of thinking styles was conducted by using the Matching Familiar Figure Test (MFFT) instrument which had previously been proven for its validity and reliability [4]. MFFT consisted of 13 questions. Each question contained two parts of pictures, the main picture and the selected picture. There were eight selected pictures in each question. For the students, they had to choose one selected picture that was exactly the same as the main picture. The result of identifying the thinking styles of the 7.1 SMP A students is presented in table 1.
Table 1. The Test Result of the Students’ Thinking Styles in 7.1 SMP A

| Cognitive Styles    | Number of Students | Percentages (%) |
|---------------------|--------------------|-----------------|
| Reflective          | 24                 | 75              |
| Impulsive           | 6                  | 18.75           |
| Quickly Precise     | 0                  | 0               |
| Slowly Imprecise    | 2                  | 6.25            |

Table 1 manifests that, in 7.1 SMP A, there are 24 students having a reflective thinking style, 6 students having an impulsive thinking style, 2 students having a slowly imprecise thinking style, and none of the students having a quickly imprecise thinking style. Furthermore, the identification result of the students’ thinking styles in 7C SMP B can be viewed in the following table 2.

Table 2. The Test Result of the Students’ Thinking Styles in 7C SMP B

| Cognitive styles    | Number of Students | Percentages (%) |
|---------------------|--------------------|-----------------|
| Reflective          | 15                 | 62.5            |
| Impulsive           | 4                  | 16.7            |
| Quickly Precise     | 2                  | 8.3             |
| Slowly Imprecise    | 3                  | 12.5            |

Anchored in table 2, it is known that, in 7C SMP B, there are 15 students having reflective thinking styles, 4 students having impulsive thinking styles, 2 students having quickly precise thinking style, and 3 students having slowly imprecise thinking styles. Continuously, the result of identifying students’ thinking styles in & 7 PK.1 SMP C is presented in table 3.

Table 3. The Test Result of the Students’ Thinking Styles in PK.1 SMP C

| Cognitive styles    | Number of Students | Percentages (%) |
|---------------------|--------------------|-----------------|
| Reflective          | 23                 | 95.8            |
| Impulsive           | 0                  | 0               |
| Quickly Precise     | 0                  | 0               |
| Slowly Imprecise    | 1                  | 4.2             |

Table 3 shows that, in 7 PK.1 SMP C, there are 23 students having reflective thinking styles, 1 student having a slowly imprecise thinking style, and none having impulsive and quickly precise thinking styles. The types of the students’ thinking styles are determined based on the time and frequency of the errors they make in answering questions at MFFT [5]. MFFT is a typical instrument used to determine the types of thinking styles based on the conceptual tempo. The criteria used to determine the students' thinking styles are based on the time median and frequency of errors that may occur [6].

Warli concludes in his research that in order to choose the same picture as the main or standard picture of the 13 items, the ideal time is maximally 14.56 minutes, and the median is 7.28 minutes. Meanwhile, the number of errors that may occur is 13, so the median is 7. Thus, reflective students have a time criterion of > 7.28 minutes and the error frequency of < 7 questions. Impulsive students have a criterion of time ≤ 7.28 minutes, and the error frequency of ≥ 7 questions. Quickly precise students have a time criterion of ≤ 7.28 minutes, and the error frequency of < 7 questions. In addition, slowly imprecise students have time criterion of > 7.28 minutes, and the error frequency of ≥ 7 questions [7].

After conducting the test of thinking styles, a misconception diagnostic test was further carried out by using a four-tier diagnostic test. The four-tier instrument used was firstly validated with CV (Content Validity) of 0.8 so that the instrument was valid and feasible to use. The four-tier test consisted of 18 questions. To successfully deal with each question, the students had to go through four
stages of the questions. First, they had to answer the main questions. Second, they had to choose the level of confidence in answering the main questions. Third, they had to choose the reasons underlying the answers to the main questions. Fourth, they had to choose the level of confidence in choosing the reasons underlying the answers to the main questions. The diagnostic test result of the students' misconceptions of 7.1 SMP A is presented in table 4.

**Table 4. The Result of the Students' Diagnostic Test in 7.1 SMP A**

| TS | % of Misconceptions | TS | % of Misconceptions |
|----|---------------------|----|---------------------|
| SI | 83.3                | R  | 61.1                |
| R  | 44.4                | R  | 55.6                |
| R  | 55.6                | R  | 55.6                |
| R  | 33.3                | R  | 55.6                |
| R  | 61.1                | R  | 72.2                |
| I  | 83.3                | R  | 55.6                |
| R  | 55.6                | I  | 77.8                |
| R  | 27.8                | I  | 83.3                |
| I  | 83.3                | SI | 77.8                |
| R  | 55.6                | R  | 44.4                |
| R  | 72.2                | I  | 83.3                |
| R  | 22.2                | R  | 38.9                |
| R  | 72.2                | R  | 44.4                |
| I  | 77.8                | R  | 44.4                |
| R  | 55.6                | R  | 66.7                |
| R  | 44.4                | R  | 72.2                |

Note:
TS: Thinking Style

Based on table 4, it is known that some students having reflective thinking styles experience misconceptions on photosynthetic and plant respiration materials with a lower percentage than those having impulsive and slowly imprecise thinking styles. Furthermore, the result of the diagnostic test for misconceptions of 7C SMP B is presented in table 5.

**Table 5. The Result of the Students' Diagnostic Test in 7.1 SMP A**

| TS | % of Misconceptions | TS | % of Misconceptions |
|----|---------------------|----|---------------------|
| QP | 66.7                | R  | 66.7                |
| R  | 66.7                | I  | 100                 |
| I  | 88.9                | R  | 72.2                |
| I  | 88.9                | R  | 66.7                |
| R  | 66.7                | R  | 72.2                |
| R  | 44.4                | SI | 77.8                |
| R  | 72.2                | R  | 55.6                |
| R  | 72.2                | R  | 27.8                |
| R  | 72.2                | R  | 55.6                |
| QP | 61.1                | SI | 83.3                |
| R  | 72.2                | I  | 94.4                |
| R  | 66.7                | SI | 77.8                |

Note:
TS: Thinking Style

Table 5 also shows that some students having reflective thinking styles experience misconceptions on photosynthetic and plant respiration materials at a lower percentage than those having impulsive
and slowly imprecise thinking styles. Likewise with the students who have quickly precise thinking styles, these students experience misconceptions with a lower percentage than those having impulsive and slowly imprecise thinking styles. The result of the misconception diagnostic test of the students in 7PK.1 SMP C is presented in table 6.

Table 6. The Result of the Students' Diagnostic Test in 7PK.1 SMP C

| TS | % of Misconceptions | TS | % of Misconceptions |
|----|---------------------|----|---------------------|
| SI | 83.3                | R  | 27.8                |
| R  | 50                  | R  | 61.1                |
| R  | 44.4                | R  | 55.6                |
| R  | 61.1                | R  | 5.6                 |
| R  | 50                  | R  | 33.3                |
| R  | 50                  | R  | 44.4                |
| R  | 66.7                | R  | 16.7                |
| R  | 27.8                | R  | 38.9                |
| R  | 55.6                | R  | 50                  |
| R  | 38.9                | R  | 61.1                |
| R  | 55.6                | R  | 22.2                |
| R  | 66.7                | R  | 44.4                |

Note:
TS: Thinking Style

The result of the misconception diagnostic test in table 6 also manifests that some students having reflective thinking styles experience a lower percentage of misconception than those who have slowly imprecise thinking styles.

Figure 1. The Percentage Comparison of Misconceptions Based on Students’ Thinking Styles in SMP A

Figure 2. The Percentage Comparison of Misconceptions Based on Students’ Thinking Styles in SMP B

Based on figure 1 and after the analysis, the average percentage of misconception of the students who have impulsive and slowly imprecise thinking styles is higher than those who have reflective thinking styles. Furthermore, the result of the analysis in figure 2 indicates that the average percentage of misconceptions of the students that have impulsive and slowly imprecise thinking styles is higher than those who have reflective and quickly precise thinking styles. The result of analysis in figure 3 also shows that the average percentage of misconceptions had by the students having slowly imprecise thinking styles is higher than those who have reflective thinking styles. Reflective students are those with a long record of time and a low frequency of errors in answering the questions. Impulsive students
are those with a quick time record but a high frequency of errors in answering the questions. Quickly precise students are those with a quick record of time and a low frequency of errors in answering the questions. In addition, slowly imprecise students are those with a long record of time and a high frequency of errors in answering the questions [4].

![Figure 3. The Percentage Comparison of Misconceptions Based on Students' Thinking Styles in SMP C](image)

The errors made by the students refer to the existence of misconceptions that arise in answering various questions given. Through diagnostic test conducted at three different schools, it is seen that students with impulsive and slowly imprecise thinking styles experience a higher percentage of misconceptions than those having precise and reflective thinking style. The result of this study is expected to be used as the source for a new discourse and reference to make an effort to remediate misconceptions and to widen the knowledge to conduct other studies.

4. Conclusion
The result indicates that students with impulsive and slowly imprecise thinking styles experience a higher percentage of misconceptions than those having quickly precise and reflective thinking styles. Through the result of this study, teachers are advised to identify misconceptions based on the students' thinking styles in other subject matters so that they can make further efforts to remediate the misconceptions that occur.

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