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Conceptual understanding of high school students on plantae

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ABSTRACT

Kingdom Plantae is a topic taught in Grade Tenth in Indonesia high school. The previous researchers have found misconceptions and difficulties in understanding the classification and the nomenclature system of Kingdom Plantae. Understanding basic concepts of Kingdom Plantae is important to study the more complex system of Plantae. This research was aimed to analyze the conceptual understanding of high school students on Plantae. The participants were 372 eleven graders who had studied Kingdom Plantae and selected randomly from eleven high schools in Surakarta, Indonesia. The diagnostic test four-tier consisting of 20 items. The instrument was to identify conceptual understanding. The instrument showed result on validity (mean = 1.00 and SD = 0.06) and reliability (0.46). The test showed that 10.5% students grouped as understand, and the test varied as to False Negative (4.4%), False Positive (10.1%), Lack of Knowledge (45.6%), and Misconception (29.4%). Based on the results of the test, the students have misconceptions about monocots and dicots, the morphology of Anacardium occidentale, Musa sp., and Solanum tuberosum, classification of Anacardium occidentale. It was recommended to do detail examination of the reasons of low achievement in conceptual understanding of students.

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1. INTRODUCTION

Kingdom Plantae is a topic which is taught in grade X, includes classification of plants from the lower level to higher level, characteristics, and behavior, reproduction, and the roles for life. Generally, the characteristics of plants are to have roots, stems, leaves, and chlorophyll. However, in certain cases, there are some creatures that possess plant-like features but do not belong to plant groups, such as non-plant fungi for lacking of chlorophyll.

Many students face difficulties related to misconceptions when learning this topic. Students' difficulties, according to Zarisma, Qurbaniah, & Muldayanti, include the understanding of characteristics, the structure of plant body, reproduction system, classification, and function [1]. Meanwhile, according to Vitharana, students have misconceptions on the concept of food transportation in plants [2].

Difficulties in understanding concept are the problems not only for senior high school students but also for students in all levels of education. In elementary level, students' misconceptions occur in the concept of plant's structure and function [3], even some of them called the fungi are plants [4]. According to American Association for the Advancement of Science, misconceptions of living environment are experienced by primary and junior high school students [5]. Junior high school students have misconceptions on the concept photosynthesis [6], photosynthesis and respiration [7], and parts of the plant [8]. Meanwhile,

misconceptions occurring at the university level are about the concept of photosynthesis and plant respiration [9], plant classification [10], and cellular respiration [11].

Learning about the Kingdom Plantae in Indonesia tend not to be contextual. Students make use of a learning source, a textbook. Meanwhile, it does not have the detail facts about Plants. The students did not make dirct observations to get to know the plants in the environment. Also, they are not facilitated to observe plants directly in surrounding and observe plants which are mostly used in societies' everyday life. The lack of introduction to the surrounding environment leads to confusion when encountering an object. The confusion may lead to students' misconceptions. If the misconceptions are experienced, it will be difficult to clarify a concept which is considered appropriate, but indeed scientifically inappropriate.

Learning about Plantae is so important for students because this concept is a basic concept in the biology before they are learning about the concepts of biology in the next level. If the students do not understanding about this concept, so they are difficult to understand the next concept about Plantae.

It needs a way to overcome difficulties since the concept is important for the students. The way that students can learn Plantae easily by providing understanding on it. The students who have mastered the concept will be able to remember it which has been learned in a long period to make the learning meaningful [12]. Concept understanding is strongly emphasized for students earlier through explaining and introducing our surrounding environment directly using touch and smell [3]. If students are not provided with concept understanding earlier, misconceptions will possibly happen to the students. Students' misconception will be difficult to identify and fix[13].

Teachers should understand students' initial concept before starting learning about Plants. One of the ways to do so is conducting a diagnostic test[14]. According to Suwarto, the diagnostic test is a test which can provide information about concept understanding and ways to cope with students' difficulties [15]. In line with Suwarto, Haslam & Treagust postulate that diagnostic test is used to identify the misconceptions of a group of students [7]. The diagnostic test is a strategy to understand students' initial conceptions on a certain topic [16].

In this research, the diagnostic test was developed by taking the form of four-tier multiple choice. This test is the improvement of previous test forms (first-tier, two-tier, and three-tier) which still have drawbacks, one of which is incapability of identifying students' conceptions in details [17]. Diagnostic test is not only used in biology, but also in other fields of study like mathematics [18], molecular[19], chemistry [20-22], physics [23, 24], astronomy [25], and even psychiatry [26], psychology [16], and economics [27].

Based on the explanation, the research problem was how to comprehend the concept of the plant in grade X high school student in Surakarta. By the problem statement, this study aimed at investigating concept understanding of grade X high school students in Surakarta.

2. RESEARCH METHOD

This study was carried out from November 2016 to February 2017 in 11 senior high schools in Surakarta with a total of 372 samples of grade X students. Samples of schools were selected by using purposive sampling technique, and samples of students were chosen by using random sampling technique. The number of students participating in this research, approximately 30 students for each school shown in Tabel 1, it was determined by using disproportionate stratified sampling proposed by Isaac $\left[S = \frac{X^2 \times N \times P(1-P)}{d^2(N-1)+X2P(1-P)}\right]$.

Table 1. Schools and Number of Students Participated in the Present Research

Name of High School	Type of School	Number of Samples (students)
SMA Negeri 1 Surakarta	Public	33
SMA Negeri 2 Surakarta	Public	31
SMA Negeri 6 Surakarta	Public	32
SMA Negeri 8 Surakarta	Public	33
MA Negeri 1 Surakarta	Public, Islamic School	36
MA Negeri 2 Surakarta	Public, Islamic school, boarding	37
SMA Batik 1 Surakarta	Private, general	35
SMA Batik 2 Surakarta	Private, general	30
SMA ABBS Surakarta	Private, Islamic School	33
SMA MTA Surakarta	Private, Islamic School	34
SMA Kristen 1 Surakarta	Private, Christian school	38
TOTAL		372

The test was one way to obtain data understanding of student concepts. The test used was four-tier multiple choice diagnostic test. The form of test presentation was by providing a statement with the true or false answer, the confidence intervals of 1-5, and the reasons of four choices (a-d) of answers for questions, as well as confidence intervals of 1-5. The test consisted of 20 questions on Plants. Then the researcher tested the students' understanding by using the instrument of the diagnostic test. The students took the test for 45 minutes.

The test instruments were validated by using QUEST Program. The instrument showed the result on validity (mean = 1.00 and SD = 0.06) and reliability (0.46). based on the result, the items that showed are valid and the measurement give a consistent result. Data of measurement results were later analyzed and categorized based on the categorization proposed by Gurel, Eryılmaz, & McDermott [28] shown in Table 2

Table 2. Criteria of Diagnostic Test Four-Tier

1st tier	2nd tier	3rd tier	4th tier	Decision four-tier test
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	FP, Rarely MSC
Correct	Sure	Wrong	Not sure	LK
Correct	Not sure	Wrong	Sure	LK
Correct	Not sure	Wrong	Not sure	LK
Wrong	Sure	Correct	Sure	FN
Wrong	Sure	Correct	Not sure	LK
Wrong	Not sure	Correct	Sure	LK
Wrong	Not sure	Correct	Not sure	LK
Wrong	Sure	Wrong	Sure	MSC, Rarely MTK
Wrong	Sure	Wrong	Not sure	LK
Wrong	Not sure	Wrong	Sure	LK
Wrong	Not sure	Wrong	Not sure	LK

Information: FN (False Negative); FP (False Positive); LK (Lack of Knowledge); MSC (Misconception); SC (Scientific Conception); and MTK (Mistake).(Gurel, Eryılmaz, & McDermott, 2015)

By those categories, students' conception achievement can be categorized into three: students understood the concept (SC), students did not understand the concept (LK and FN), and students have misconception (FP and MSC).

3. RESULT AND DISCUSSION

Figure 1 presented the results of concept understanding measurement of grade X students in Surakarta on the topic of Plants. All participating students responded variously to 20 items of conception test. A few number of students comprehensively understood the concept of Plantae, i.e., 10.5 % was in the SC category. While the rest were categorized as "not" or "not yet understand" the concepts, with the detail are as follows: FN was 4.4%, FP was 10.1%, LK was 45.6%, and MSC was 29.4%. Sagap, Husain, and Djirimu said that the high score that student can achieve indicates the understanding level of students regarding the concepts [29]. Unfortunately, in fact, there were a small number of students who understood the concepts very well, whereas the number of students who just guessed the answer due to lack of conceptual understanding was higher than ones have perfect understanding.

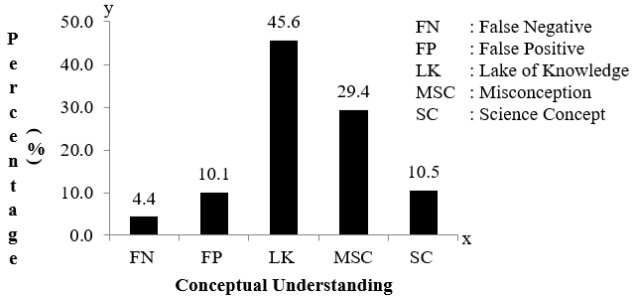


Figure 1. Distribution of students' conceptual understanding on plantae

A large number of students who only guessed the answers is possibly attributable to multiple choice test form. Multiple choice tests had some drawbacks: the students had more tendencies to only to guess the answers and can not assess students' thinking processes. Sometimes, even though students do not understand the concept, they can choose one of the available answers, and it helps them to make it easy to answer questions. However, this test also has some strengths: this type of evaluation is objective, the process for correcting the responses is easier and faster, this test includes all taught materials, and it is appropriate for a diagnostic test.

In more detailed, students' understanding of the topic of Plants was based on each item, as presented in Table 3. Most of the students experienced misconception when answering items 1, 4, 5, 6, and 13. On the contrary, students could understand the concept when answering item number 7. Meanwhile, students only guessed for the remaining items (2, 3, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, and 20) from the available choices.

Table 3. The Understanding of Grade X Students in Surakarta

Item	Concept	Students' Understanding Achievement (%)				
		FN	FP	LK	MSC	SC
Item 1	Characteristic of monocots and dicots	9.4	4.3	36.0	**48.7**	1.6
Item 2	Characteristic of monocots and dicots	19.1	2.2	**40.3**	38.4	0.0
Item 3	Characteristic of monocots and dicots	1.6	17.7	**44.1**	32.3	4.3
Item 4	The body structure of plants	1.6	3.8	26.3	**63.2**	5.1
Item 5	Classification of Plants	0.3	3.2	36.3	**53.5**	6.7
Item 6	The body structure of plants	3.2	10.8	33.6	**48.9**	3.5
Item 7	The habits/behaviors of plants	6.5	5.1	35.8	8.9	**43.8**
Item 8	Plant Reproduction	0.5	5.1	**48.4**	39.5	6.5
Item 9	Plant Reproduction	8.1	7.0	**39.8**	13.7	31.5
Item 10	Classification of Plants	5.1	20.4	**42.2**	12.1	20.2
Item 11	The body structure of plants	1.6	14.7	**60.1**	13.6	10.1
Item 12	The body structure of plants	3.5	11.3	**68.5**	14.0	2.7
Item 13	Plant Reproduction	1.3	3.2	37.9	**42.2**	15.3
Item 14	Classification of Plants	1.9	19.4	**53.5**	25.3	0.0
Item 15	Classification of Plants	6.7	13.2	**42.7**	32.0	5.4
Item 16	Classification of Plants	4.6	4.6	**50.8**	8.1	32.0
Item 17	The body structure of plants	2.7	11.3	**50.5**	33.3	2.2
Item 18	Classification of Plants	3.5	3.2	**59.4**	28.8	5.1
Item 19	The body structure of plants	6.7	10.8	**50.8**	22.0	9.7
Item 20	The body structure of plants	0.0	30.1	**55.1**	9.4	5.4
Average		4.4	10.1	45.6	29.4	10.5

On item 1, the number of students who understood the concept (1.6%) was lower than those who did not understand. Most students experienced misconceptions (48.7%) due to their lack of understanding of the differences between monocotyledon and dicotyledon plants. Item 1 is a statement that the stem of monocotyledon plants does not have any branch. Most of the students responded well because they knew about one of the characteristics of monocotyledon plants that almost all monocotyledon plants, is the absence of branches. However, in fact, there are some monocotyledon plants with branches. *Cordyline* sp. (*Andong*, *Hanjuang*, ti plant) is an example of monocotyledon plant with branches [30]. Therefore, the statement is false.

Similar to item 1, item 2 showed that no students were found to understand the differences between monocotyledon and dicotyledon concepts (SC = 0%). Most students only guessed the answer. The result reveals that 40.3% of students decided either true or false of statement "Monocotyledon plants have parallel venation, while dicotyledon plants have palmate/ pinnate venation" by guessing. Most students agreed with the statement, but the reason behind their choice contradicted the statement, and they were unsure when answering.

Item 3 asked about a plant mostly found in Indonesia, banana plant. The statement is "Musa sp. (the banana plant) is a monocotyledon plant having pinnate venation." The results of the research indicate that 4.3% of students understood the concept, while 44.1% merely guessed that the statement is false, gave an incorrect reason, and felt sure about the answer. They considered that *Musa* sp. has parallel (instead of pinnate) venation and belongs to monocotyledon plants with parallel venation, whereas in fact that monocotyledon plants are recognized by single cotyledon (or seed leaf). Therefore, although Musa sp. has pinnate venation, it is still included as a monocotyledon. Students had no understanding of the concept of monocotyledon plants, particularly *Musa* sp. in details.

Students' misconception is found in item 4 which was also discussed about a plant mostly found in Indonesia and commonly used by Indonesia societies, *Anacardium occidentale* (the cashew tree). Students

were asked to identify 'the fruit' of the cashew tree. The results of the research indicate a low level of students' understanding (SC=5.1%), it showed students' misconception of *Anacardium occidentale*, and demonstrated that 63.2% of students considered green/ yellow/ red cashew apple as the fruit, whereas in fact, it is the swollen stalk of the true fruit, cashew nut. Most people think that cashew nut is the seed of *Anacardium occidentale*.

Item 5 was still related to *Anacardium occidentale*. The statement given is "*Anacardium occidentale* belongs to gymnosperms." The results of the research show that only 6.7% of students understood such concept, while 53.5% stated that *Anacardium occidentale* belongs to gymnosperms since they considered "the cashew nut" as the seed, and "the swollen stalk" as the fruit, and concluded that seed is uncovered by the fruit. In fact, such concept is inappropriate [31]. It seemed that the students had a misconception of a division of *Anacardium occidentale*.

Item 6 tested students' knowledge on *Musa* sp. (the banana plant) with a statement "The stem of *Musa* sp. is termed *debog pisang* (false stem/trunk)". The results of the research indicate that 3.5% of students understood the concept. Most of the students recognized the stem as debog pisang in the form of layers. In fact, *debog pisang* is not the stem, but rather it is formed by the tightly packed overlapping leaf sheaths. Meanwhile, the true stem is almost invisible since it is very short and is indeed underground stem (rhizome) which grows up through the center [32]. The students who experienced misconceptions about banana tree trunk amounted to 48.9%.

Out of 20 items posted, only item 7 were found to be well understood, one of which is a concept of *Dendrobium crumenatum* (the pigeon orchid), a parasitic plant growing on *Mangifera indica* (the mango tree). Such concept was well-understood by 43.8% of students. On this item, display figures of Loranthus and *Dendrobium crumenatum* (mulberry mistletoe) on mango trees to compare, and a statement "The pigeon orchid is not a parasitic plant." Several students stated that *Dendrobium crumenatum* does not belong to parasitic plants although it grows on and absorbs water from a host. The pigeon orchid captures CO_2 from the air as the carbon source for photosynthesis [33]. In fact, a plant is considered parasitic if growing on a host, absorbing water, nutrition, and CO_2 from the host, and doing photosynthesis.

On item 8, 48.4% of students had not understood the concept of the statement "*Arachis hypogaea* (peanut) is included as root tuber." Most of the students answered by guessing that the statement was true since they believed that the plant grows underground. The percentage of students who understood the concept is 6.5%. In fact, a peanut plant has long side branches which become heavy with developing flowers, each of which produces a stem called a peg, the embryo of the developing peanut that turns horizontal to the soil, buries itself, and produces a nut [34]. Most of the students gained no understanding of such concept due to the underground location of the fruit.

The students did not understand about the concept also occured when students were given a statement about mosses (item 9), "Mosses reproduce using not only spores." The statement is true. In fact, mosses reproduce in two phases – first by gametes and then by spores [35]. The research revealed that there were a fewer number of students who understood the concept (SC=31.5%) and 39.8% of students answered by guessing. Most of the students believed that the statement is true and selected a correct reason, but felt unsure about the answer.

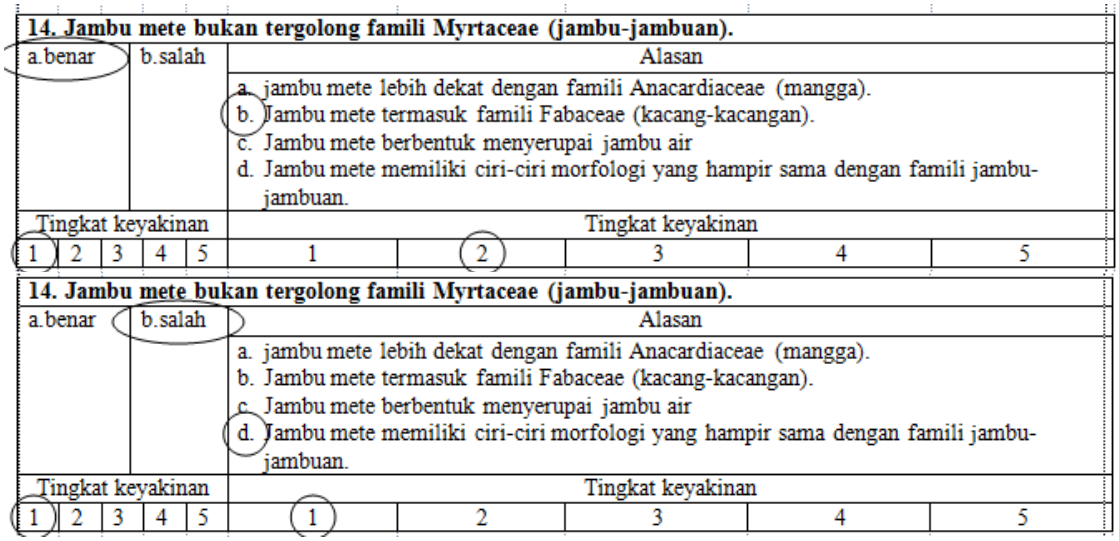
The students considered item 10 "*Gnetum gnemon* (paddy oat) belongs to monocotyledon" as a true statement. The item showed students' lack of understanding of the concept of gymnosperm and angiosperm. In fact, *Gnetum gnemon* is a gymnosperm [36]. The results of the research pointed out that 20.2% of students understood such concept, but 42.2% selected the correct answer but provided an inappropriate statement. In short, students answered item 10 by guessing.

The students made correct answer and selected correct reason on the statement of item 11 "*Bougainvillea* flowers are tiny and yellow-white," but they were unsure about the answer. It is true that *Bougainvillea* flowers are tiny and yellow-white and the colorful parts which look like Corollas are indeed bracts, specialized leaves surrounding the true flower [30]. The percentage of students who understood the concept is 10.1%, and 60.1% admitted that they guessed the answer.

Item 12 presents a figure of *Canna hybrida* (Indian shot) and statement "A part of *Canna hybrida* which during this time is considered as corolla is indeed a stamen." The statement is true, but many students thought that the part is a corolla, so that they made incorrect answer [37]. The research denoted that 2.7% of students understood the concept, while 68.5% guessed the answer.

On item 13, student have misconceptions about *Solanum tuberosum* (potato). The statement that was given to the students was "*Solanum tuberosum* is root tuber". Students thought that Solanum tuberosum is root tuber since it grows underground and stores food reserves in roots, whereas in fact, *Solanum tuberosum* belongs to stem tubers with the swollen tip of an underground stem due to the food reserves [38]. The percentage of students who understood such concept is 15.3%. The item indicated the highest percentage of students experiencing misconception (MSC=42.2%).

There are no students who understood (SC=0%) the concept of item 14's statement "*Anacardium occidentale* is not classified as the family of *Myrtaceae* (guava family)." The results of the research indicated that 53.5% of students guessed the answer. They thought that *Anacardium occidentale* belongs to the family of *Myrtaceae* (guava family), whereas in fact, *Anacardium occidentale* has a closer kinship to the family of *Anacardiaceae* (the mango family) because the fruit looks very similar to a heart like a mango [39].



14. Jambu mete bukan tergolong famili Myrtaceae (jambu-jambuan).

a.benar	b.salah	Alasan
		a. jambu mete lebih dekat dengan famili Anacardiaceae (mangga). b. Jambu mete termasuk famili Fabaceae (kacang-kacangan). c. Jambu mete berbentuk menyerupai jambu air d. Jambu mete memiliki ciri-ciri morfologi yang hampir sama dengan famili jambu-jambuan.

Tingkat keyakinan					Tingkat keyakinan				
1	2	3	4	5	1	2	3	4	5

14. Jambu mete bukan tergolong famili Myrtaceae (jambu-jambuan).

a.benar	b.salah	Alasan
		a. jambu mete lebih dekat dengan famili Anacardiaceae (mangga). b. Jambu mete termasuk famili Fabaceae (kacang-kacangan). c. Jambu mete berbentuk menyerupai jambu air d. Jambu mete memiliki ciri-ciri morfologi yang hampir sama dengan famili jambu-jambuan.

Tingkat keyakinan					Tingkat keyakinan				
1	2	3	4	5	1	2	3	4	5

Figure 2. Examples of diagnostic tests four-tier and student answers for item 14

On the concept of statement "*Cycas* sp. (cycad family) does not belong to ferns and fern allies", 5.4% of students did not gain understanding. Most students merely guessed the answer regardless the real concept (LK=42.7%). Most students also confirmed the statement but included an inappropriate reason. For them, *Cycas* sp. belongs to *Arecaceae* (the palm family) since the tree resembles the palm tree, whereas in fact it is included in the family of *Cycadaceae* (cycad family) [40].

Item 16 presented about of ferns and fern allies, which details *Adiantum* sp. (maidenhair fern) and displays its figure completed with the statement "A Plants that have these characteristics is a group gymnospermae (naked seed)." The research demonstrated that 32% of students understood the concept, and 50.8% of them answered by guessing. In fact, *Adiantum* sp. belongs to ferns and fern allies since it is nonflowering plant [41], and therefore the statement is false. Although many students guessed the answer with appropriate reason, they felt unsure about their chosen answer.

Item 17 displayed figure of *Physalis Angulata* (cut leaf groundcherry) showing its fruit and calyx. Students considered its calyx as the peel of fruit [42] but felt unsure about the answer. The percentage of students who understood the concept is 2.2%, while the students who merely guessed the answer due to lack of understanding is 50.5%.

Test on item 18 (statement: "*Borassus flabellifer* (palmyra palm) has palmate leaves") revealed that there were fewer students who understood the concept of monocotyledon plants (SC= 5.1%). Palmyra palm is dicotyledon. Most students thought that the statement on the item was true since one of the characteristics of dicotyledons is having palmate/ pinnate leaves, whereas in fact, the statement is false. Borassus flabellifer is monocotyledon since it only has one cotyledon in spite of its pinnate venation [43]. The percentage of students who did not understand the concept and consequently answered by guessing, as indicated by the incongruity between statement and reason, is 59.4%.

On item 19, many students were found not to understand the concept of *Cocos nucifera* (coconut) represented by the statement "The edible part of *Cocos nucifera* is indeed not the fruit." The statement is true since the coconut water is the liquid endosperm, while the white and fleshy part is thick albuminous endosperm [44]. Many students considered that the statement was false, but the reason was correct. The incongruity between statement and reason showed that students merely guessed the answer. The percentage of students who guessed the answer is 50.8%, while that of students who understood the concept is 9.7%.

Item 20 presented figure of *Euphorbia* (spurge) and a statement "the colorful parts are the false corollas." The statement is true. The parts considered as corollas are indeed the bracts (modified leaves

directly beneath the flower). The research denotes that 55.1% of students guessed the answer, while 5.4% understood the concept.

Biology/science misconceptions occured due to the teacher did not clarify immediately the student's presumptions of something and was less sensitive to the misconception student [7]. Also, other causes of misconception are methods and teaching materials in schools are less precise, requiring teachers to update knowledge by the advancement of the era [45]. The misconception is the concept of someone who is inconsistent with the concepts of experts [46]. Köse defined misconception as the development of students' concepts which are inappropriate and different from scientific concepts, as well as potentials of preventing the emergence of meaningful and permanent learning process [47].

4. CONCLUSION

The number of students who understood the concept of Plants was fewer than the students who did not. Students who did not understand the concept include 45.6% who answered by guessing, 29.4% who experienced misconceptions, 10.1% who were false negative, and 4.4% who were false positive. The concept of plants that can be understood by students is the concept of the habits/behaviors of plants. On the other hand, the concepts that were not understood yet by students are about characteristic of monocots and dicots, plant reproduction, classification of plants and the structure of plants, and students tend to experience misconceptions on concepts characteristic of monocots and dicots, the body structure of plants, classification of plants, and plant reproduction. Therefore, further study was required on misconceptions of concepts of monocotyledon and dicotyledon, classification of plants, the structure of plants as well as students' reasons of experiencing such misconceptions using similar or perfected instruments.

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