Diagnosis of ecosystem misconceptions for high school students in Jakarta

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ABSTRACT

Misconception is a condition of different concepts that are owned by scientific concepts. Misconceptions impact learning processes and outcomes, so teachers need to make reductions. The first step to reduce misconceptions is to find the data on students' misconceptions. This study aims to diagnose high school students' misconceptions about ecosystems. The survey method research used a three-level multiple-choice test to diagnose ecosystem misconceptions. The research sample were 200 high school students from five high schools in Jakarta, Indonesia. The sample from each school were 40 students. The results showed that students' understanding of concepts was spread over six levels: understanding concepts, false positive misconceptions, false negative misconceptions, misconceptions, guessing or understanding concepts but lacking confidence, and not understanding concepts with a misconception percentage of 21.41%. Based on the analysis of the ecosystem sub-concept, the highest misconception occurred in the energy flow sub-concept (25.39%) and the second highest in the biogeochemical cycle sub-concept (20.41%). Teachers can use the findings as a basis for designing effective learning to reduce misconceptions so that optimal learning processes and results can be achieved.

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1. INTRODUCTION

Biology is learning that is rich in concepts. Concepts are implicit and explicit schemes or theories regarding how knowledge is connected to other pieces of knowledge. Concepts are the basis for thinking in the form of ideas that can help individuals understand a phenomenon [1]. Concepts are basic elements of knowledge [2]. Students must properly understand these concepts. Concepts in science learning are abstract and interconnected [3], so it will not be easy to relate them to the next concept when students do not understand a concept. Weak mastery of concepts has an impact on student learning outcomes, too.

Students are expected to master the concepts in biology learning. One of the concepts that students in learning biology must master is the concept of ecosystems. The reality in the field shows that there are misconceptions about learning biology. Misconception is a condition where students' conceptions differ from scientific conceptions [4]. Misconceptions occur when students defend their concepts where these concepts differ from those of experts.

Misconceptions in biology learning, as revealed by the following research [5]–[7]. Misconceptions are found in biology concepts, such as the concepts of respiration, photosynthesis, genetics, protein synthesis, classification of protists, human anatomy, physiology, evolution, and ecosystems [8]–[10]. Research also revealed that 39.59% of samples had an inaccurate conceptual understanding of ecosystem material [11].

Various factors cause misconceptions that occur in students. Research studies on the factors that cause misconceptions include Widiyatmoko and Shimizu [12] stating that what contributes to student misconceptions is the everyday experience, the language used, teachers, and textbooks. Students' intuitive reasoning is in many cases also at the core of students' misconceptions [13]. Factors that cause misconceptions include the students themselves, learning methods, teaching methods, and context [14]. Other research reveals misconceptions can be caused by people, culture, family members, mistakes in delivering the concept by the teacher, books, teaching materials, media, context, as well as learning methods [15]. Scientific misconceptions are often discovered in formal education through interactions between teachers and students. Educators who teach science concepts with certain strategies without realizing it may strengthen and spread misconceptions [1].

If the misconceptions in learning continue, it will impact student learning processes and outcomes [2]. Misconceptions make it difficult for students to understand subsequent concepts [1], and students need to be aware of their misconceptions. Misconceptions will make learning more difficult [16], so learning outcomes could be more optimal. Misconceptions create another challenge because they are stable in individual cognitive structures, recurring, resistant to change, often unconscious, and will continue interfering with students' biology concept learning processes [17]. If the misconceptions are not immediately corrected with the right conception, it can be a bias and a barrier for students in forming advanced scientific concepts correctly [18], [19]. Misconceptions can be integrated into cognitive structures and will last until the students grow up and will be more difficult to handle. Several misconceptions are resistant and difficult to change [20]. Efforts are needed to detect and reduce misconceptions [15].

Misconceptions are sometimes not realized by students and also escape the teacher's attention, which the teacher considers not important [21]. The first step to reduce the misconception is to diagnose students' misconceptions. Teachers need to diagnose students' misconceptions. Diagnosing students' misconceptions is a substantial step toward increasing understanding [22]. Data from this diagnosis is used as a basis for efforts to reduce misconceptions.

Misconceptions can be diagnosed using instruments, including interviews, open tests, multiple-choice tests, tiered tests, and sequential tests [15], [23], [24]. In this study, the instrument used is the ecosystem misconception diagnostic test (EMD test) with the characteristics of a three-tier multiple choice test presented on the Google Form platform. The choice to use this instrument is based on several reasons: a three-level multiple-choice instrument can distinguish between those who lack knowledge and those who have misconceptions. This instrument can easily identify students' understanding of concepts and only requires a short time [25]. This instrument can diagnose student understanding through the pattern of students' answers. Three-tier multiple choice test can easily identify misconceptions and distinguish them from those who lack knowledge by using the level of confidence [15], [26], [27].

This misconception diagnostic is intended to understand students' misconceptions about the ecosystem concept. This diagnostic is important because misconceptions will have an impact on low learning outcomes. The learning process will be more difficult for students if students experience misconceptions. Misconceptions diagnostic results can be used as a basis for teachers in designing learning that can reduce misconceptions, so that the learning process can take place optimally and optimal learning outcomes can be achieved.

2. METHOD

Diagnosing ecosystem misconceptions was conducted using a survey method on high school students in Jakarta. The students in the research sample were students in grades X-XII (first to third grade) of high school who were studying ecosystem biology material, with varying academic abilities. The research sample was determined using a purposive sampling technique. In qualitative research, sampling is very appropriate if it is based on the research objectives or problems, using the researchers' considerations to obtain the accuracy and adequacy of the information needed according to the objectives or problems being studied [24]. Samples based on this concept can range from n=1 to n=40 or more [25]. The sample in this study amounted to 200 students spread across five schools. Apart from diagnosing student misconceptions, interviews were also conducted with biology teachers at the five schools.

Data was collected using the EMD test instrument in a three-level multiple choice form using the Google Forms platform. The instrument consists of the first level (one-tier) in the form of ordinary multiple choice, the second level (two-tier) in the form of reason choices, and the third level (three-tier) in the form of affirmation questions about the beliefs of the answers that have been chosen at levels one and two [17]. Giving reasons at the second level is important for detecting misconceptions and knowing why students have misconceptions [2]. A three-level test can distinguish the lack of knowledge from misconceptions [28]. The three-level test is considered more accurate in identifying student misconceptions because it can detect misunderstandings by using the level of confidence in the answers given by students [15]. Instruments were distributed through biology teachers. Misconceptions are diagnosed based on competencies that students in ecosystem material must master. The competencies in ecosystem material studied in class X senior high school written in Permendikbud number 37 of 2018 in basic competencies 3.10 can be seen in Table 1.

Table 1. Indicators of achievement of ecosystem competency

Indicators of achievement		Sub-concept competency
3.10.1.	Explaining the definition of ecosystems	Ecosystems and ecosystems components
3.10.2.	Identifying the components of the ecosystem	
3.10.3.	Identifying types of interactions between ecosystem components	Interactions between ecosystem components
3.10.4.	Explaining the mechanism of energy flow in an ecosystem and related to the balance of the ecosystem	Energy flow
3.10.5.	Analyzing the role of various ecosystem components in the biogeochemical cycle	Biogeochemical cycle
3.10.6.	Analyzing the linkages of various processes that occur in the biogeochemical cycle with everyday life	

The validity of the instrument was analyzed using point biserial correlation analysis. There were 30 instrument items used with an average point biserial correlation coefficient of 0.67. Instrument reliability is determined using the Kuder-Richardson 20 formula [29]. The reliability coefficient value obtained based on calculations is 0.79 for level one instruments with high-reliability criteria, 0.84 for level two instruments with very high criteria, and 0.87 for level three instruments with very high criteria. The results of the student's misconception diagnosis are interpreted in six categories of conceptual understanding, as shown in Table 2. Furthermore, the scores resulting from the misconception diagnosis are grouped into four levels: very high, high, medium, and low, as shown in Table 3.

Table 2. Interpretation of student concept understanding [28]

Response type			Concept understanding categories
Level 1	Level 2	Level 3	
Correct	Correct	Sure	Understand the concept
Correct	Wrong	Sure	Misconceptions (false positives)
Wrong	Correct	Sure	Misconceptions (false negatives)
Wrong	Wrong	Sure	Misconceptions
Correct	Correct	Not sure	Guess or understand the concept but lack confidence
Correct	Wrong	Not sure	Lack of knowledge
Wrong	Correct	Not sure	Lack of knowledge
Wrong	Wrong	Not sure	Lack of knowledge

Table 3. Criteria for grouping the level of concept understanding [30]

Levels	Score intervals
Very low	<41.00
Low	41.00–55.99
Medium	56.00–70.99
High	71.00–85.99
Very high	86.00–100.00

3. RESULTS AND DISCUSSION

3.1. General description of students' misconceptions

The EMD test instrument was distributed to high school biology teachers in Jakarta, Indonesia. Valid data was obtained from 200 students that spread across five schools. Based on the results of the analysis, it was found that students were spread across six categories of concept understanding. The results of the analysis is can be seen in Table 4.

The results of the diagnosis of students' understanding of concepts in ecosystem material showed that the lowest percentage was that students guessed or understood concepts but lacked confidence, at 4.41%. Students categorized as understanding concepts occupy the highest percentage of 39.87%, and those who lack knowledge are 10.25%. Table 4 also shows that students who are categorized as having misconceptions are 21.41%, 19.20% are categorized as false positive misconceptions, and 5.08% are categorized as false negative misconceptions.

Table 4. Distribution of students in each concept understanding category

Concept understanding category	Percentage (%)
Understand concept	39.87
Misconceptions (false positives)	19.20
Misconceptions (false negatives)	5.08
Misconceptions	21.41
Guess or understand concepts but lack confidence	4.41
Lack of knowledge	10.25

Based on the results obtained, some students still experience misconceptions about ecosystems. These results align with previous research on ecosystems [31], [32]. Students are scattered in conditions of understanding concepts, not knowing concepts, and misconceptions, with the highest percentage being in misconceptions. This finding shows that 21.41% of students still need help to clear up their misconceptions, construct, and understand concepts well and correctly. Misconceptions about the concept of ecosystems are very likely to occur because, in daily life, students can observe various natural phenomena or problems related to the concept of ecosystems [33]. When interacting with the environment, students can conceptualize concepts according to their thoughts, and these thoughts may not follow scientific concepts. Students' misconceptions are built through connections with the surrounding environment [34]. When interacting with the surrounding environment, implicit reasoning unconsciously influences students' thinking to interpret natural phenomena [13].

Using everyday language outside scientific language can lead to misconceptions among students [3]. In addition to language, students get wrong explanations from the surrounding environment, so that students may misinterpret the true meaning of the concept. This is also reinforced by the condition of the ecosystem concept that has been studied by students in formal learning at schools, starting from elementary to high school levels. Observations and experiences gained by students from the surrounding environment and through formal education allow students to interpret ecosystem concepts independently. Students' intuitive reasoning also leads to the development of inaccurate ideas [35]. Interpretation or the results of students' interpretations related to these concepts can be contrary to the scientific opinion of experts, thus causing misconceptions. The learning strategies used by biology teachers are undoubtedly the cause of students' perceptions about how difficult biology concepts are, and misconceptions occur, leading to low biology learning achievement [36].

Learning in the current digital era makes it easier for students to connect to various learning resources. Students will easily get information on learning materials from various sources. However, this convenience can also lead to misconceptions if students are unprepared or cannot use digital technology. The use of information technology applications by students who are not ready to obtain teaching materials can also lead to misconceptions [31]. The causes of misconceptions can be from the students themselves, wrong initial concepts, student reasoning, wrong cognitive development processes, reference books for learning, and teachers in conveying material [36], [37]. Wrong initial concepts will color, direct, and sometimes obstruct students' understanding of a scientific concept [38].

Misconceptions will encourage further misconceptions [19]. Students who experience misconceptions cannot accept new knowledge and will experience mistakes repeatedly until they realize that the concepts they believe are correct are wrong [39]. The role of the teacher is very important to make students aware of their misconceptions because it makes students aware that their beliefs are wrong and will encourage them to adopt the point of view of the scientific community [40]. Students who experience misconceptions must be treated to make them realize their mistakes and construct new scientific concepts. Cognitive conflict strategies are one of the treatments that teachers can use [37], [41], [42].

The survey results found that 19.20% of students experienced false positive misconceptions. False positive misconceptions are conditions where students answer questions at the first level correctly but with the wrong reasons, but students believe the answer. False positive misconceptions describe that students have the correct understanding of claims, but they cannot explain these claims [43]. Conditions like this could mean that the students need help understanding the concept, or it can be said that students have the right answers but have the wrong concepts. Students who were confident with wrong answers are likelier to have misconceptions regarding consistent and stable cognitive structures [44]. Misconceptions in this situation are difficult to eliminate because clearing misconceptions is difficult [42]. Meanwhile, false negative misconceptions are conditions where students answer questions at the first level incorrectly but with the right reasons, but students believe in these answers. According to Kirbulut and Geban [17], a false negative is the answer chosen at level one is correct, and the reason chosen at level two is wrong. However, students have believed the two answers they have chosen. False negative misconceptions illustrate that students do not have true knowledge claims but can explain these claims. This category is considered negative because it is likely that the answers given are guessed answers that happen to be correct [43]. This condition can be interpreted as the student gaining little understanding (less information), or it can be said that the student has the wrong answer but has the correct concept. Misconceptions in this situation are not considered problematic because they are caused by students' carelessness in choosing answers.

In Table 4, it is also seen that students who have lack of knowledge are 10.25%. Lack of knowledge is indicated by the EMD test when students provide uncertainty responses at level three. In line with the opinion [28], lack of knowledge is uncertain regardless of the right or wrong answer at the first or second level. Lack of knowledge is different from misconceptions [45], but lack of knowledge can result in misconceptions [40]. Lack of knowledge also has an impact on student learning progress, which does not develop optimally [43].

Based on the diagonal results, 4.41% of students have lack of self-confidence. A lack of confidence is not being sure whether to answer correctly [42]. Conditions of lack of confidence should not be allowed in students because lack of confidence is a barrier to learning [46]. Trust plays a role in one's growth mindset, where the growth mindset influences one's success in various fields [47].

3.2. Details of students' misconceptions of the ecosystem sub-concept

The results of a more in-depth review of student misconceptions about each ecosystem sub-concept as measured by the EMD test can be seen in Figure 1. Based on the figure, it can be observed that the highest misconceptions occur in the energy flow sub-concept with the results at 25.39%, followed by biogeochemical cycle material at 20.41%, ecosystems and ecosystem components at 14.07%, and the lowest is interaction between ecosystem components with 13.07%. The energy flow sub-concept is the most difficult sub-concept to understand. The data shows that most students cannot understand decomposers and detritivores and then associate the two terms. Wrong word associations play a role in constructing cognitive errors in students. Students will have difficulty receiving new information following the concept [48].

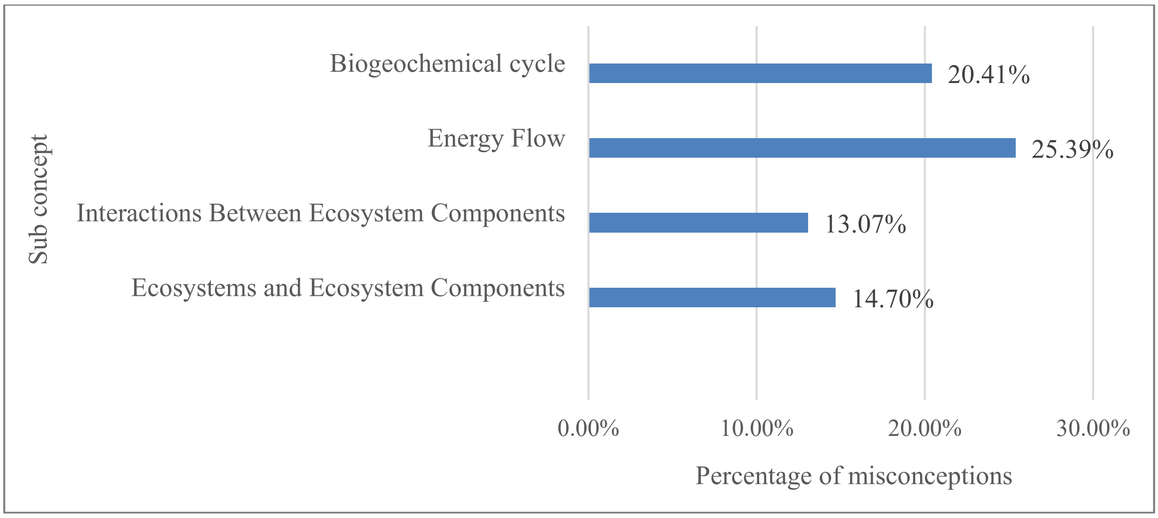

Figure 1. Percentage of student misconceptions on the ecosystem sub-concept

Some students have difficulty explaining the energy flow on earth, misperceptions often occur between food webs and ecological pyramids, and students are less able to understand biogeochemical cycles that occur because of complicated recycling processes. Abstraction and complexity of concepts can lead to misinterpretation of concepts [15]. The teacher only uses government books, PowerPoint slides, and blackboards to explain during class. The teacher admitted that this material was difficult to explain because the material's content had to be memorized, and students needed visualization. These results were revealed based on interviews with high school biology teachers.

The active role of students during the learning process also has an impact on the construction of concepts. A passive attitude that tends only to receive information causes errors in reasoning and building understanding. Students must be actively involved in learning and in constructing understanding. The experience of constructing understanding will lead students through stages of conceptual change and eventually lead to scientifically accepted conceptions [49]. Active involvement of students in learning can also develop higher-order thinking skills, including 4C skills (creativity, critical, collaboration, and communication) [50]. An overview of the conditions of understanding the concepts of high school students in Jakarta based on the six categories of concept understanding in each of the ecosystem sub-concepts can be seen in Table 5.

Table 5 shows that students' mastery of concepts is best in sub-concept 3.10.3 (identifying types of interaction between ecosystem components). This is because, in this sub-concept, students can take examples from interactions in their environment and daily life. They often observe this interaction so that the concept becomes easier to understand. In line with the opinion [8], contextual familiarity will facilitate understanding. Interaction with the environment can teach students new scientific concepts [24]. Individuals unconsciously use the use of analogies with more familiar entities to build cognitive bridges to more complex and abstract concepts [19].

Table 5. Conditions of students' conceptual understanding of each ecosystem sub-concept

Concept understanding category	Indicators of competence achievement					
	3.10.1 (%)	3.10.2 (%)	3.10.3 (%)	3.10.4 (%)	3.10.5 (%)	3.10.6 (%)
Understand concept	22.8	27.7	64.4*	42.5	33.2	32.8
Misconceptions (false positives)	54.2*	30.1	7.5	13.2	20.4	26.4
Misconceptions (false negatives)	3.5	18.3*	6.3	4.6	3.0	2.4
Misconceptions	11.6	17.8	13.1	25.4*	23.0	17.8
Guess or understand concepts but lack confidence	0.5	0.5	1.5	4.6	7.2*	7.1
Lack of knowledge	7.6	5.1	7.3	10.0	13.6	14.1*

Note: *the highest percentage for each category

Sub-concepts 3.10.4 and 3.10.5 (sub-concepts of energy flow and biogeochemical cycles) need to get full attention from teachers because these sub-concepts have the highest percentage of misconceptions compared to other sub-concepts and students who lack knowledge in these sub-concepts are also higher than on other sub-concepts. It takes effort from the teacher to overcome misconceptions. Teachers must reflect critically on their learning [51]. Teachers must care about students' misconceptions [16], [52] and try to reduce them. Misconceptions can be overcome with effective instructional interventions designed by teachers based on identifying misconceptions [2], [53]. Providing direct learning experiences, involving students actively in the learning process, and selecting appropriate learning situations and assignments can correct misconceptions [2], [37], [54]. Clarifying students' misconceptions by the teachers is one effort to reduce misconceptions. Research by Aptyka *et al.* [8] found that students who studied without clarifying misconceptions experienced significantly more misconceptions than those studying with clarifying misconceptions. Teachers can improve students' e-readiness skills, metacognitive awareness, and biology literacy to minimize high school students' misconceptions about biology [31]. The use of cognitive conflict strategies will affect students' conceptual transformation [55] so that misconceptions will be reduced [37].

Another influencing factor of misconceptions is from the students themselves [36], which is the need for more accuracy in examining the questions so the students will answer correctly. Some students answered by reasoning about the questions and associating them with concepts, but the reasoning needed to be corrected. Students' lack of understanding caused this. The causes of the students themselves can also be measured from student answers, namely one of the false positive misconceptions in sub-concept 3.10.1 is 54.2%, sub-concept 3.10.4 is 13.2%, and in sub-concept 3.10.5 is 20.4%. Students answer the first level correctly, then the reasons chosen at the second level are wrong; the third level is sure of these conditions, which can be interpreted that in these conditions, students do not understand the concept (lack of understanding). Misconceptions in this situation are very difficult to eliminate because students believe in the answers given. Students need to realize that they have misconceptions.

3.3. Diagnostic score

Based on the diagnosis results we carried out on 200 high school students, test score data grouped into very low, low, medium, high, and very high [30]. An overview of the percentage of students based on the score obtained from the misconception diagnosis can be seen in Figure 2. Based on the figure, it can be seen that out of the 200 Jakarta high school students who were diagnosed, the highest distribution was in the medium category. The second highest is in the low category. This picture can provide information that for ecosystem material, the achievement of conceptual understanding by high school students is not very good. In other words, ecosystem material is challenging for high school students. Ecosystem material has a complicated concept [32]. Most of the students are in the medium category, which could also be due to the complexity of the ecosystem material, the need for systems thinking, and understanding of ecosystems also heavily depends on students' initial understanding and conception [56].

Referring to the data in Table 4, there are 10.29% of students who have lack of knowledge, meaning that 10.29% of students do not have an accurate conceptualization [28]. Teachers need to strive for students to build correct conceptions because students' well-developed conceptions in science will lead to students' development and achievement in science education [24]. An overview of students' conceptual understanding of a material can be feedback for the teacher to determine the level of understanding and misconceptions that remain after the learning process is complete [37]. In teaching students, the complexity of the material needs to be considered by the teacher. Teachers need to simplify concepts when they present new ideas to the students [57].

If it relates to the results of the diagnosis of misconceptions, it turns out that students' misconceptions align with the acquisition of their learning outcomes. Misconceptions will affect the process and learning outcomes [16], [58]. Misconceptions contribute to poor academic achievement [59] and cause low achievement in studying biology [36]. Understanding the concepts and conditions of student misconceptions are different according to their level of achievement [6]. An overview of the results distribution of the misconception diagnosis at each score level can be seen in the Figure 3.

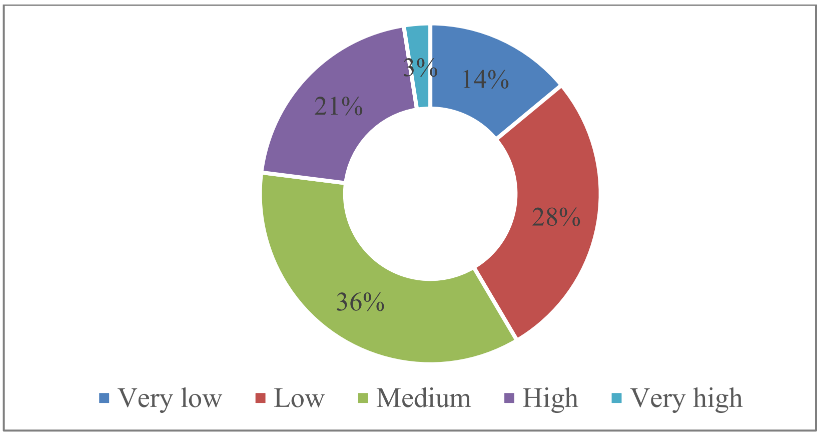

Figure 2. Percentage of students based on misconception diagnosis scores

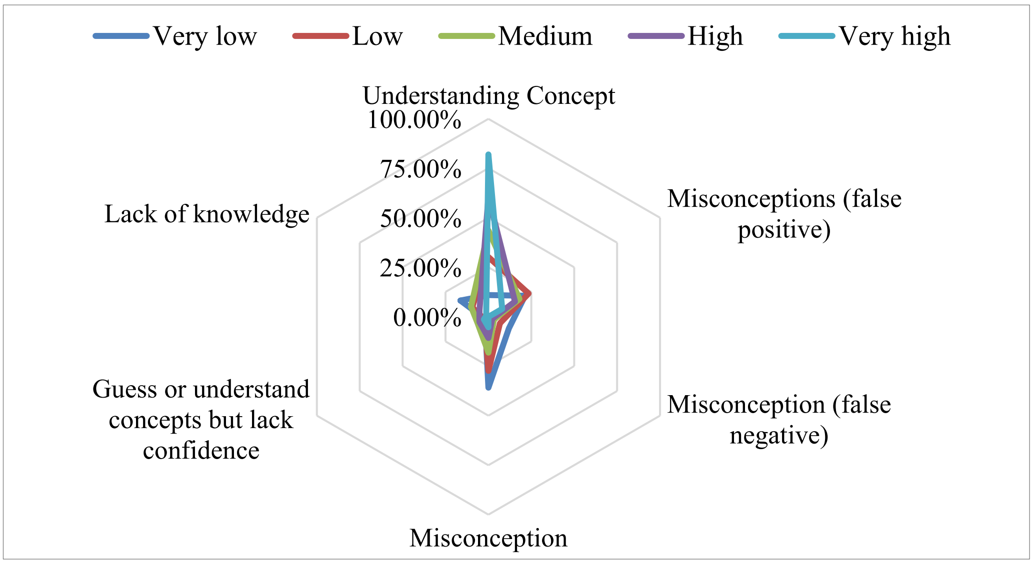

Figure 3. The distribution of students in the six concept understanding categories based on the concept achievement score

The very high group of students showed the highest average percentage of understanding the concept at 82%. The highest average percentage of false positive misconceptions was obtained by the low group at 23.39%. Meanwhile, the very low group obtained the highest average percentages of false negative misconceptions, misconceptions, and lack of knowledge at 11.90%, 35.83%, and 16.31%. The medium group obtained the average percentage of guessing or understanding the concept but lacked confidence at 6.29%.

These results must be a concern for the teacher to teach students according to their conditions, especially regarding reducing misconceptions. Interventions must be carried out differently according to the students' conditions because one effort to overcome misconceptions is through clarifying misconceptions. Clarifying misconceptions can be effective for students with higher initial knowledge but obstruct students with lower prior knowledge [8]. Each student requires different treatment to correct his misconceptions [15] and learning must be understood as an active, individual, situational, social, and cognitive psychological process [60]. Each student experiences a different level of learning progress, level of understanding, and construction of knowledge [43].

The teacher's teaching style is very important to note. Research by Jeno *et al.* [61] recommends that teachers adopt a teaching style that supports autonomy, for example, by providing meaningful reasons when opening lessons so that students feel more competent and independent in their motivation. The teacher must give an explanation of the learning objectives and the usefulness of learning for students' lives.

Diagnosing misconceptions is very important for a teacher so the teacher can focus on solving these misconceptions. Learning planning is adjusted to the results of the class diagnosis, and the same action cannot be given to all classes. The study results by Wells *et al.* [62] state that it is important to diagnose the misconceptions to make them the basis for lesson planning. Adjustment to student conditions is needed to overcome misconceptions that remain after learning and prioritize resources to overcome these misconceptions.

The results of the diagnosis found in this study can certainly be the basis for teachers to design effective learning. Effective learning was designed to reduce misconceptions and facilitate the construction of correct concepts. Misconceptions are considered in instructional design as a mechanism to help identify the understanding students should develop through learning [53]. Diagnosed misconceptions are used as educational resources that are useful for involving students in authentic learning experiences, not considered obstacles that require total replacement [22]. Learning that ignores previous knowledge (including misconceptions) and does not involve students in the discovery process will potentially increase misconceptions because, in general, new students have misconceptions obtained from previous education [37]. Before starting learning, teachers must better understand where their students are (what their initial knowledge is) what misconceptions they have, and where those misconceptions come from [63]. Differentiated learning used in the independent curriculum needs to pay attention to various aspects of student characteristics, such as prior knowledge and types of brain hemisphere preferences, not limited to variations in learning style characteristics.

4. CONCLUSION

The findings in the study showed that high school students in Jakarta are spread across six categories of conceptual understanding of ecosystem material. The percentage of students who understand the concept is 39.87%, false positive misconceptions are 19.20%, false negative misconceptions are 5.08%, and misconceptions are 21.41%. The diagnostic results also found that 4.41% of students took the test by guessing or understanding concepts but needed more confidence, and 10.25% needed more knowledge or accurate concepts. The analysis of concept mastery in the ecosystem sub-concept found that the highest misconception was in the energy flow sub-concept at 25.39%, and the second highest was in the biogeochemical cycle sub-concept at 20.41%. These two sub-concepts need more attention from the teacher because, in these two sub-concepts, the percentage of students who lack knowledge is also higher than in the other sub-concepts. Analysis of the diagnosis score obtained an overview that the high school students in Jakarta are spread on an average of the medium. Based on these results, it can be interpreted that the ecosystem material is the material that is not easy for students. These results can be as an information for students about the condition of understanding their concepts, and for teachers can be used as a basis for designing effective learning interventions, so that students' misconceptions can be reduced, correct understanding of concepts can increase, and the learning process takes place effectively, as well as optimal learning outcomes in the material ecosystem can be achieved. The diagnosis carried out in this research was still limited to 200 students, but certainly a survey needs to be carried out with a larger sample size so that the conclusions are more comprehensive. Further research is also needed for a more in-depth analysis of the factors that cause misconceptions and efforts that can be made to reduce them.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
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I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

No conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [EPA], upon reasonable request.

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