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The development of ecosystem misconception diagnostic test

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ABSTRACT

Misconception is a problem that is often found in learning biology concepts. Ecosystem concept is one of the biology concepts in which misconceptions are found a lot. As a learning problem, misconceptions need to be addressed as soon as possible. The purpose of this research is to produce a valid and reliable diagnostic test instrument for misconceptions in the form of a three-tier multiple choice test which is presented through Google Form platform. This development research applied the research and development method with a 4D development model. The developed diagnostic test instrument was validated by two expert validators and obtained a mean score of 3.27 (very feasible). Through the results of item validation, from 40 questions there are 30 valid items with an average correlation coefficient value of 0.67 and 10 invalid items with an average correlation coefficient value of 0.10. The diagnostic test instrument was also tested for readability to students and got an average value of 3.41 (very feasible) and was tested for readability to teachers and got an average value of 3.74 (very feasible). This shows that the developed product is very valid and reliable to be used as a diagnostic test instrument for misconceptions.

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1. INTRODUCTION

Misconception is an understanding, idea, or view that is strongly attached and gives a different meaning from the concept accepted by experts [1]–[8]. Misconceptions are problems in learning that are important to be addressed immediately because they tend to form patterns of trust and are believed by students because they are considered more logically connected [3], [5]–[15]. If it is not immediately corrected with the right conception, misconceptions can become a bias and barrier for students in forming advanced scientific concepts appropriately and can be integrated into their cognitive structures, also will last until students mature and will be increasingly difficult to handle [3], [9], [14], [16]–[21].

Misconceptions that occur in students are often found in biology learning [6], [22]–[26]. The concept of ecosystem is a biological concept in which the most misconceptions are found [7], [23], [27]. It happened because there are many events, phenomena, experiences, or observations of the surrounding environment that makes students learn concepts informally and form misconceptions [28]. Misconceptions in biology learning are a challenge, because usually students and teachers are not aware of it [29], [30]. It happened because in learning activities, misconceptions are rarely carried out [31]–[34]. To be able to deal with misconceptions which are one of the learning difficulties [5], first teachers must have data related to students' misconceptions obtained through various measurement tools or diagnostic instruments.

Compared to other measuring instruments or diagnostic instruments, the misconception diagnostic test instrument in the form of the three-tier multiple choice test is considered more valid and reliable in

identifying students' misconceptions [35]. It is because of this test can distinguish misconceptions from lack of knowledge with level of confidence item. This item allows students to express how sure the answers and reasons have been given to certain questions [8], [15], [21], [35], [36].

Most of the misconceptions diagnostic tests that have been developed so far are found in paper and pencil format [18], [21], [24]. The implementation of a diagnostic test in the form of a paper based test (PBT) has drawbacks, it requires a lot of time and money in terms of presenting, analyzing, and generalizing information about students' misconceptions [37]. These problems can be solved by using a diagnostic test instrument that is integrated with information communication technologies (ICT). The use of digital diagnostic test instruments can provide many advantages. It increases effectiveness and efficiency in presenting, conducting diagnostics, and processing diagnostic results [38]. In addition, testing the use of digital diagnostic instruments is also able to increase the efficiency of data use because the data can be recorded and stored properly.

There are many platforms that can be accessed easily and free, one of which is Google Forms. Google Forms is a free digital web-based assessment or evaluation platform. It has various features including the "make a copy" and "import question" features that will facilitate the use of diagnostic test instruments that will be developed to be used as evaluation instruments which also have a diagnostic function of misconceptions [39]–[41]. Through this background, this research needs to be carried out with the aim of being able to produce a product in the form of an EMD-Test which is a diagnostic test instrument for misconceptions of the ecosystem concept in the form of a three-tier multiple choice test which is presented using the Google Forms platform which is valid and reliable.

The novelty of this research is to produce an evaluation instrument that has been linked to material content at a predetermined formal school level which also has a diagnostic function of misconceptions. The developed EMD-Test diagnostic test instrument is considered to be more accurate and efficient in identifying misconceptions because it is presented digitally via google forms and presented in the form of a three-tier test with the number of options at each level that is adjusted to the misconceptions found in the literature [3], [8], [18], [21], [26], [40], [42], [43]. In addition, the items at the second level are also equipped with options for filling in other misconceptions that students have that have not been successfully revealed in the literature.

2. RESEARCH METHOD

The research and development model used as a reference for product development is a 4D model consisting of define, design, develop, and disseminate [44], [45]. The subjects of product development testing including item validity tests in this development research were 68 XI grade (second-year) mathematics and natural sciences students at SMAN "X" (senior high school) Jakarta, Indonesia who had studied the concept of ecosystems. Consisting of 37 males and 31 females. Meanwhile, the subject of the product development readability test was 69 XI grade mathematics and natural sciences students at SMAN "X" Jakarta consisting of 37 males and 21 females, also 2 biology teachers at SMAN "X" Jakarta. There are several instruments used to collect data in this development research. The techniques and instruments used for data collection can be seen in Table 1.

Table 1. Data collection techniques and instruments

No	Stage	Technique	Instrument	Target
1.	Define	The definition stage is carried out using a literature study technique.		
2.	Design	The design stage is carried out using literature study techniques.		
3.	Develop	EMD-Test product feasibility test	Questionnaire	Biology education expert
		Development testing	EMD-Test product development (revised initial draft)	Learners
		Readability test of students	Questionnaire	Learners
		Teacher readability test	Questionnaire	Teacher
4.	Disseminate	No data collection		

The research procedure refers to the 4D research and development model which has four stages referring to Khamid and Thiagarajan [45], [46]. The first stage is define. This stage consists of several activities, such as front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives. Front-end analysis and learner analysis activities were carried out using literature study techniques. Task analysis done by analyzing the results of the front-end analysis and learner analysis results. Concept analysis activities are carried out by analyzing the main parts of the ecosystem subject matter [46]–[48]. While the last step at the definition stage is carried out by compiling indicators of competency achievement based on the results of concept analysis and curriculum analysis.

The second stage is design. This stage consists of several activities, such as constituting criterion-referenced tests, media selection, format selection, and initial design. This stage begins by searching for information in the literature related to students' misconceptions that usually occur in the ecosystem concept. At this stage the format of the questions is determined, a grid of questions for 40 items, question texts, answer keys, scoring guidelines and interpretation of the results are also made. In addition, media that can display or present products effectively are also selected [45], [48].

The third stage is develop. This stage consists of several activities namely expert appraisal and developmental testing. The expert assessment step is carried out referring to [49], by involving two lecturers who are experts in the field of biology education who will be given a questionnaire. Developmental testing activities are carried out after revisions are made based on suggestions for improvement from experts. This step was carried out by testing the EMD-Test instrument product to students and teachers at SMAN "X" Jakarta. The last stage is disseminate. The disseminate stage in this study was carried out by distributing the final product in a limited way to biology teachers at SMAN "X" Jakarta.

Because in this study there are various kinds of data, as can be seen in Table 1, the data analysis was carried out in stages according to the type of data. The results of expert appraisal, student readability tests, and teacher readability tests were analyzed using quantitative analysis techniques with reference to the interpretation table from [50], as can be seen in Table 2. The results of expert appraisal, student readability tests, and teacher readability tests were analyzed with the help the Microsoft Excel application.

Item validity, reliability, and the level of difficulty of the EMD-Test instrument questions in this study was analyzed from the results of the development testing by first giving a score to the students' answers. The scoring of item validity, reliability, and level of difficulty of the EMD-Test instrument questions is given as done in previous research [43], which can be seen in Table 3. In Table 3, the score is given in each tier of the questions and coded as 1 or 0.

Table 2. Validity and readability test score interpretation [50]

Interval	Criteria	Information
$3.25 \leq x \leq 4.00$	Very valid	Can be used without revision
$2.50 \leq x < 3.25$	Valid	Can be used with minor revisions
$1.75 \leq x < 2.50$	Less valid	Can be used with multiple revisions
$1.00 \leq x < 1.75$	Invalid	Cannot be used yet and requires consultation

Table 3. Scoring captions for data analysis

Score	Information
1	If students answer the first level item correctly, they will be given a code of 1, while incorrectly they will be given a code of 0.
2	If students answer the first and second level items correctly, they will be given a code of 1, while incorrectly they will be given a code of 0.
3	If students answer the first, second, and third level items correctly, they will be given a code of 1, while incorrectly they will be given a code of 0.
Confidence level item score	If students answer "sure" for the confidence level item, they will be given a code of 1, while if they answer "not sure" they will be given a code of 0.

The validity of the items in this study was tested by calculating the biserial point correlation coefficient. The validity of the items in this study was analyzed with the help of the Microsoft Excel application. While the reliability in this study was determined using Kuder Richardson 20 and also with the help of the Microsoft Excel application. The calculation of the difficulty level in this study uses (1) [51].

$$P = \frac{B}{JS} \quad (1)$$

Where, P is difficulty index, B is the number of students who answered the questions correctly on each question item, and JS is number of test takers.

The results of the difficulty index are then interpreted as the quality of the questions per item by looking at Table 4. According to the table, there are several qualities of questions namely hard, moderate, and easy. These several qualities of questions were determined by looking at difficulty index interval in Table 4. Students' answers at the development testing stage were also interpreted into several categories of concept understanding. Guidelines for interpreting students' understanding of concepts can be seen in Table 5. Students' understanding was interpreted into six concept understanding category.

Table 4. Difficulty index interpretation [52]

Difficulty index interval	Quality of questions
0.00≤P<0.30	Hard
0.30≤P<0.70	Moderate
0.70≤P<1.00	Easy

Table 5. Interpretation of student concept understanding [53]

Response type			Concept understanding category
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	Misconception
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

3. RESULTS AND DISCUSSION

3.1. Define

3.1.1. Front-end analysis

Through literature study, it can be seen that in biology concepts there are still many misconceptions that occur in various biology concepts at all levels of formal education [6], [22]–[26]. This misconception can be a problem because it can hinder the learning process of biology. This can happen because the concepts of biology are closely related from one concept to another, and because they are closely related to the problems faced in everyday life [19], [23], [54]. One of these biology concepts, in which the misconceptions are mostly found is the ecosystem concept [7], [23], [27]. It can also be seen that one of the alternative solutions to misconceptions can be started by carrying out the identification of misconceptions [5].

3.1.2. Learner analysis

Through a literature study, it can be seen that students can actively form their own understanding through their observations of the surrounding environment, various phenomena, and the experiences they get both through formal and informal education [28]. Understanding that is formed independently by students usually contains many misconceptions that students tend to believe. It was proved by many studies that have succeeded in revealing that in biology concepts there are many misconceptions that occur in students [4], [6], [22]–[26], [28], [55]–[60].

Information was also obtained that students tend to have difficulties in memorizing and understanding biological terms [61]. Meanwhile, in terms of doing tests, students often feel unsure of the answers when working on questions. So as an alternative solution, the form of questions in the diagnostic test instrument was developed that matched these characteristics, namely the misconception diagnostic test instrument in the form of a three-tier multiple choice test [36].

3.1.3. Task analysis

Students' misconceptions regarding the ecosystem concept are difficult for students to overcome. Therefore, in overcoming students' misconceptions regarding the ecosystem concept, appropriate teacher instructional strategies are needed, namely those that focus on conceptual change. Through this step, it can be concluded that as an initial effort, it is necessary to develop a valid and reliable diagnostic test instrument for misconceptions.

3.1.4. Concept analysis and specifying instructional objectives

Through concept analysis, ecosystem concept studied at the X high school grade level written in Regulation of the Minister of Education and Culture (Permendikbud) Number 37 of 2018 in Basic competencies 3.10, namely analyzing the components of the ecosystem and the interactions between these components are chosen to be associated with the products which about to develop. In this step the main parts of the ecosystem subject matter are also analyzed. The analysis is carried out by analyzing the sub material of the ecosystem subject matter where misconceptions are found. Through this step, information about subject matter, basic competencies, sub concept, and indicators of competence achievement was obtained, as can be seen in Table 6.

Table 6. Results specifying instructional objectives

Component	Information
Subject matter	Ecosystem
Basic competencies	3.10 analyzing the components of the Ecosystem and the interactions between these components
Sub concept	Ecosystems and ecosystem components Interaction between ecosystem components Energy flow Biogeochemical cycle
Indicators of competence achievement	3.10.1 Explaining the meaning of ecosystem 3.10.2 Identify the components that make up the ecosystem 3.10.3 Identifying the types of interactions between biotic components in an ecosystem 3.10.4 Explain the mechanism of energy flow in an ecosystem and its relation to ecosystem balance 3.10.5 Analyzing the role of various ecosystem components in the biogeochemical cycle 3.10.6 Analyze the relationship of various processes that occur in the biogeochemical cycle with everyday life

3.2. Design

3.2.1. Constituting criterion-referenced tests

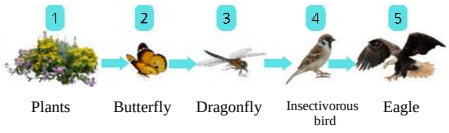
The test preparation activity begins with compiling an information table on misconceptions in the Ecosystem sub-material. Misconceptions information is found from the literature and each misconception is coded numerically so that the frequency of each misconception can be easily determined. The misconception information table containing sub-materials, indicators of competency achievement, scientific concepts, misconceptions of students' ecosystem concepts found in the literature, as well as the numerical code of misconceptions are presented in Table 7.

Table 7. Information on students' misconceptions on ecosystem concepts

Sub material	Indicators of competence achievement	Misconception	Code
Ecosystems and ecosystem components	Explain the meaning of ecosystem	An ecosystem is not a system but only a collection of organisms [9], [62]	(M-10.1)
	Identifying the components of an ecosystem	Defines abiotic components as components contained in an ecosystem that are inanimate objects [63]	(M-10.2)
Interaction between ecosystem components	Identify the types of interactions between biotic components in an ecosystem	Error in determining the type of interaction, between mutualistic interactions and protocols [6]	(M-10.3.a)
		Error in determining the type of interaction, between the interaction of parasitism and amensalism [6], [29]	(M-10.3.b)
Energy flow	Explain the mechanism of energy flow in an ecosystem and its relation to ecosystem balance	Interpret food webs using the food chain concept [6], [29], [30], [62]	(M-10.4.a)
		Organisms cannot change their trophic level [62]	(M-10.4.b)
		Populations that are higher up in the food chain are predators of all populations below them [30], [62]	(M-10.4.c)
		Decomposers are top-level consumers [9], [64]	(M-10.4.d)
		Population changes that are considered unimportant will not have an effect on an ecosystem [9], [55], [62]	(M-10.4.e)
		Changes in one population will only affect other populations if they have a direct relationship as predator and prey [30], [62], [65]	(M-10.4.f)
		Changes in the size of the prey population have no effect on the predator population, and vice versa [30], [65]	(M-10.4.g)
		Changes in size that occur in one population in a food web will occur in all other populations in the food web in the same way [9], [30]	(M-10.4.h)
		An ecosystem can be said to be balanced if it has a dominant number of producers compared to other consumers [55]	(M-10.4.i)
		Organisms that located higher up in a food chain obtain more energy than organisms that are located lower down [6], [62], [64], [66]	(M-10.4.h)
Biogeochemical cycle	Analyzing the role of various ecosystem components in biogeochemical cycles	Water only evaporates from seas and lakes [67]	(M-10.5.a)
		The material cycle is a series of linear processes that have a starting and ending point [68], [69]	(M-10.5.b)
		Students' knowledge of the material cycle is limited to systems that include non-living components [70]	(M-10.5.c)
	Analyzing the relationship of various processes that occur in the biogeochemical cycle with everyday life	Students are not aware of other factors that can affect the continuity of the water cycle [68], [71], [72]	(M-10.6.a)
		Drops of water that are outside the cold water container are water that seeps through the container [67], [71], [72]	(M-10.6.b)
		Errors in identifying the source of carbon dioxide in the air, namely carbon dioxide in the atmosphere only comes from the use of fossil fuels [64], [73]	(M-10.6.c)

The format of the question items to be developed at the first level which contain simple multiple choice questions with 2-4 options [74]–[76]; The second level questions will contain questions about the reasons for the answers to the first level and provide 3-5 reasons options with the last reason option in the form of the other reason or blanks. The blank option is expected to reveal students' misconceptions that have not been found in the literature [15]. While the third level questions will contain items that aim to reveal the level of students' confidence in the answers, they have given at the first and second levels. At this level, two options are presented, namely "sure" and "not sure". The selection of the "sure" and "not sure" options on the third level question is based on considerations of efficiency in implementing the instrument and interpreting the results, because if the confidence item is presented with an option scale of 0 to 5 for the diagnostic function of misconceptions, the scale still have to be changed to a category "sure" and "not sure". This happened because the final results that needed from the misconception diagnostic instrument are only the belief categories in the form of "sure" and "not sure" [4], [34]. After the item format is determined, the grid for the 40 question items, the question text, answer keys, and scoring guidelines are compiled. Examples of items developed are presented in Table 8.

Table 8. Example of EMD-Test items

Sub concept	Competency achievement indicators	Problem indicator	Question	Answer key	Misconception
Energy flow	3.10.4 Explain the mechanism of energy flow in an ecosystem and its relation to ecosystem balance	Presented with a food chain diagram, students can accurately determine which organisms are the prey of top-level predators	Look at the following picture!  1) In the food chain, the eagle is the top-level consumer. Eagles can be said to be top-level consumers because they can prey on organisms found in number... a. 1, 2, 3, 4 b. 2, 3, 4 c. 3 and 4 d. 4 2) Which of the following choices is the reason for the answer given earlier? a. Because each organism has a specific type of predator and prey b. Due to its role as a top-level consumer that can eat all the organisms below it c. Other reasons: ... 3) Are you sure of the answers and reasons you have given? a. Sure b. Not sure	1) D 2) A 3) A	(M-10.4.c) Populations that are higher up in the food chain are predators of all populations below [30], [62]

3.2.2. Media selection and format selection

This step is carried out by adjusting the product that about to develop, materials, user characteristics, and media that can effectively present the product. Google Form was chosen as a media that will present the EMD-Test because its use can increase efficiency in terms of cost, time, presentation, use, and storage of test data [39], [77]. Meanwhile, the format selection step in this research step is carried out by determining the form of product presentation that will be developed by designing how the product will be displayed. The product in this case will be displayed with the header, form title, work instructions, question identity, student identity and questions.

3.2.3. Initial design

The initial design step in this study was carried out by putting questions into Google Forms according to a predetermined display plan. The initial design of the EMD-Test development product can be seen in Figure 1. Figure 1(a) presented the header design and Figure 1(b) presents header display on Google Form. Furthermore, Figure 2 shows the display of questions in Google Form.

(a) (b)

Figure 1. Header display of (a) EMD-Test question header and (b) inserted headers into Google Forms

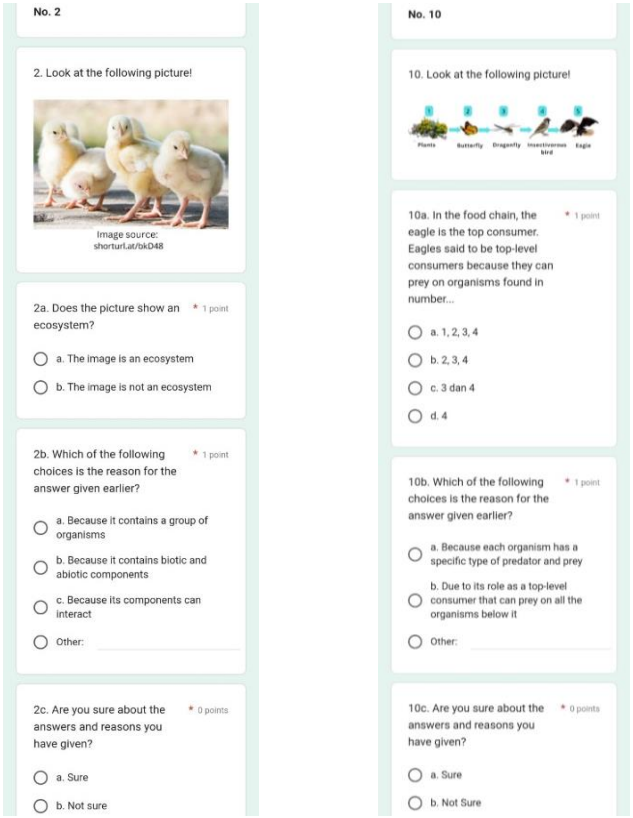


Figure 2. Display of questions that have been entered into Google Forms

3.3. Develop

3.3.1. Expert appraisal

The initial design product was then validated by two experts in the field of biology education with the aim of being able to produce practical and effective development products to overcome the problems that have been identified [45], [48]. At this stage, three aspects of the instrument are assessed, such as the material aspect, the construction aspect, and the language aspect. The average score for the material aspect is 3.33 and is in the very feasible category, for the construction aspect it is 3.36 and is in the very feasible category, and for the language aspect it is 3.12 and is in the proper category [78]. Overall, the results of the feasibility test of the EMD-Test product from the validator showed an average quality value of 3.27 which indicates that the developed EMD-Test is in the very feasible category and can be used without needing to be revised. Through these results, it can be seen that the EMD-Test product has been developed well because it is in accordance with the concept indicators or misconceptions propositions and can measure students' conceptual understanding well [2]. However, from these results it can also be seen that in terms of language aspects, the EMD-Test product still needs to be improved. This is evident from the results of the validator's suggestions which are related to the language aspect as can be seen in Table 9.

Table 9. Suggestions of validators on EMD-Test products

Suggestion	Suggestion code
Consider changing item number 1, because the pictures presented can give rise to different opinions.	SR1
Change the option in second part questions (b) because it's using the conjunction word [79]	SR2
In question number 6, the term protocooperation is too pushy to answer, look for another term from protocooperation.	SR3
The type of question number 13 is replaced slightly differently from number 12.	SR4
The type of question number 14 is changed to be different from numbers 12 and 13.	SR5
The answer choice options are attempted to be formulated with almost the same length.	SR6
The word "which" cannot be at the beginning of a sentence [79]	SR7
Change the formal form greeting word in the question part (b) and in the instructions, replace it with the more informal greeting word [80]	SR8
Add questions with cognitive level C6 and questions that present data to be analyzed.	SR9

3.3.2. Developmental testing

Through this activity, student test scores obtained with an average value of 53.90 which indicates that students' understanding of the ecosystem concept is still low. This is consistent with the science learning outcomes tested on TIMSS which showed that Indonesia was ranked 41st out of 43 countries for science learning outcomes [58]. Based on the results of this step, it also can be seen that of the 40 questions tested there are 30 valid questions and 10 invalid questions with the average biserial point correlation coefficient for 30 valid items of 0.67 and 10 invalid items of 0.10. Valid and invalid items can be seen in Table 10.

Table 10. Valid and invalid question items

No. question points	Number of items	Average of r_{pbi}	Information
1, 2, 3, 5, 6, 7, 8, 9, 11, 14, 15, 16, 17, 18, 19, 20, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, 40	30 items	0.67	Valid
4, 6, 10, 12, 13, 21, 24, 33, 34, 39	10 items	0.10	Invalid

Overall reliability of the EMD-Test instrument was then also calculated by excluding invalid items. Reliability for each question level is calculated using a score of 1, a score of 2, and a score of 3 which is entered into the Kuder Richardson formula 20. Through calculations, it can be seen that the value of the reliability coefficient obtained is 0.79 for level one questions; 0.84 for second level questions; and 0.87 for third-level questions as can be seen in Table 11. These results indicate that the developed EMD-Test instrument product is reliable and for three-level questions it has very high reliability criteria [51]. The value of the reliability coefficient on the EMD-Test instrument also increased at each additional level of the question. The increase in the value of the reliability coefficient at each additional level of the question indicates that the test developed with a three-level format is more reliable when compared to simple multiple choice or two-level format [78].

Table 11. Reliability of each question level

Question level	Value of r KR_{20}	Value of rTable	Information
One-level question	0.79	0.24	Reliable (high)
Two-level question	0.84	0.24	Reliable (very high)
Three-level question	0.87	0.24	Reliable (very high)

The difficulty level of the 40 EMD-Test items that have been developed is also calculated. Through calculations, it can be seen that there are 12 items with a quality category of difficult items, 25 moderate items, 2 easy items, and one item that has a difficulty index of 0 because none of the students answered the question correctly. namely item number 6 [52]. The difficulty index of zero obtained by question number 6 according to the biology teacher's statement at the school where the research was carried out was because neither the word protocooperation nor synergism had been studied before, so that no students answered the question correctly. The difficulty index can be used as a reference in determining the duration of the test if the EMD-Test questions are to be reused [81]. The difficulty index can also be considered as a reason why an item is not valid in the calculation of item validity. This is because the lower difficulty index could be a sign that the questions have not been developed properly [2], [34], [81].

As additional data that can be obtained from developmental testing, the results of developmental testing in this study are also interpreted into several categories of concept understanding. Interpretation is done by first removing invalid items and making adjustments to the number of questions and the distribution

of questions based on indicators of competency achievement and misconception. Interpretation is carried out with adjustments because in this study there was no dissemination stage. The percentage of students' concepts understanding is also calculated as shown in Figure 3.

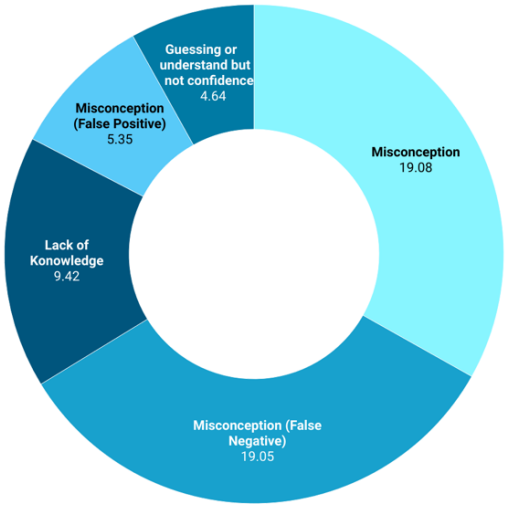


Figure 3. Percentage of students' concept understanding category

Through these calculations, it can be seen that the misconceptions that occur in students get a fairly large percentage, which is 19.08%. The number of misconceptions found in the concept of biology is considered not in line with the students' assumption that Biology concepts including the ecosystem concept is an easy concept. This assumption is what makes students tend to have low motivation in studying the subject matter of ecosystems. Besides being caused by the assumption that the ecosystem subject matter is an easy concept to learn, the low motivation of students in studying the ecosystem is also caused by the background experience of students who have studied the concept a lot at lower levels of education and the close relation of this material to daily life.

Meanwhile, the false positive misconception is a state of understanding in which students are correct in answering the first level questions but still cannot provide scientific reasons to indicate their strong understanding of the concept. This can be a sign that the learning process carried out by students is still less meaningful, so that the correct concepts possessed by students are mixed with misconception [34], [82]. The false negative misconception is a state of understanding in which students answer the first level questions incorrectly, and answer the second level questions correctly. This can be caused by student errors in choosing answers [83].

The high percentage of false positive and false negative misconceptions in this study, namely 19.05% and 5.35%, can be caused by the low literacy interest possessed by students. This statement is supported by the finding that many students immediately fill in the blank options without first reading the multiple-choice options which contain the alternative reasons that have been presented. In fact, according to the results of student responses, many students generally answered with the correct concept, even though it was not a very complete explanation. The percentage of misconceptions for each sub-concept of ecosystem material is also calculated as can be seen in Figure 4.

The highest percentage of misconceptions occurs in the energy flow sub-concept, which is 20.92%; followed by the sub-concept of interactions between ecosystem components by 19.49%; biogeochemical cycle which is 19.42%; and the lowest is ecosystem and ecosystem components, which is 11.15%. Meanwhile, the item format at the second level provides blank options, so that from the development testing stage, new misconceptions have also been obtained that have not been found in the literature. The new misconception can be seen in Table 12.

Readability test activities were also carried out in this study. The results of the readability test of students get an overall average 3.41 which means the EMD-Test product is very feasible and can be used without revision [50]. Meanwhile, through the results of the readability test of 2 teachers at SMAN "X" Jakarta, it can be seen that the EMD-Test product developed is classified as very feasible and can be used without revision with an average value of 3.74 [50]. Based on these results, it can be seen that the EMD-Test product has been developed well because it is in accordance with the material studied at the high school

level, basic competencies and competency achievement indicators, the instrument developed is in accordance with the misconceptions that often occur in students, and is easily accessible by various kinds of students. Digital devices and makes it easier to work with because it is presented through Google Forms. Nevertheless, several improvements and adjustments were made to the product so that the product could be further disseminated.

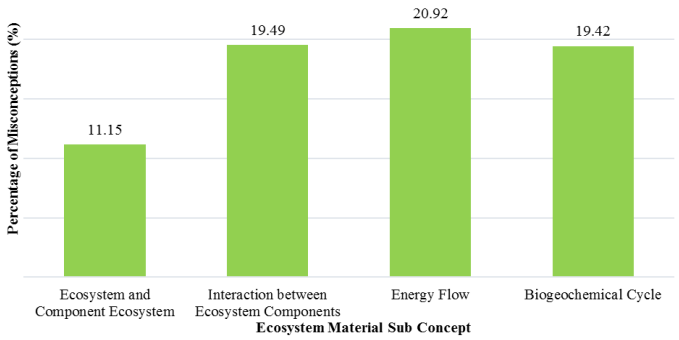


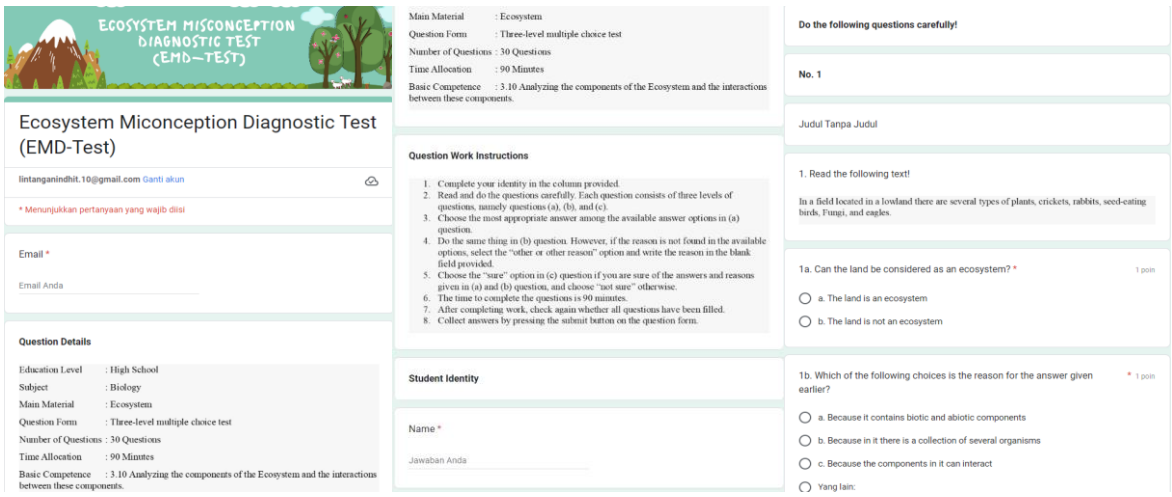
Figure 4. Percentage of misconceptions per sub-concept of ecosystem material

Table 12. Newfound student ecosystem misconceptions

No.	Newfound student ecosystem misconceptions
1.	Wrong in determining the level of organization of life (Explaining a picture that shows a population as a community).
2.	Such emission gases CO_2 can disrupt the balance of the ecosystem through the disruption of the respiration of the biotic components contained in an ecosystem.
3	The water cycle begins with the evaporation of water from the ocean or lake due to heating from the sun.

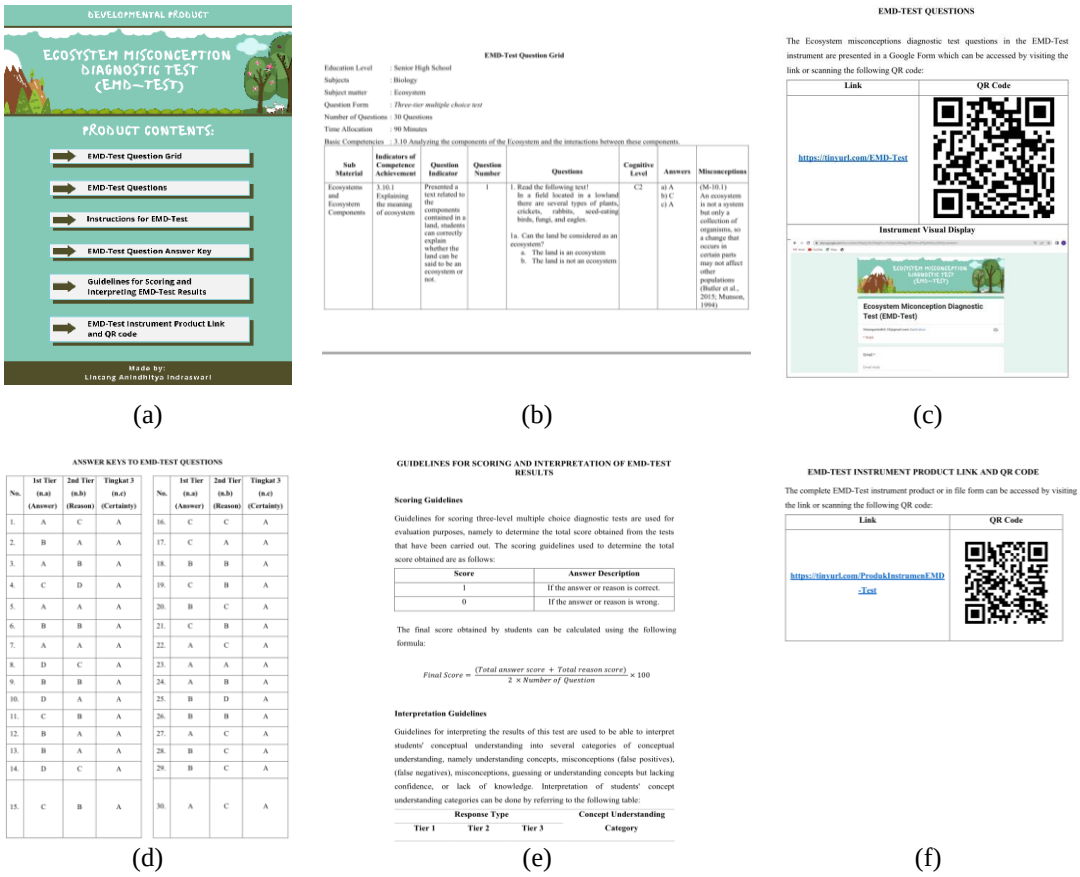
3.4. Disseminate

The dissemination was not carried out in this study because it was not the final goal of the study. EMD-Test products are distributed by links and QR codes containing EMD-Test questions presented through Google Forms and complete EMD-Test instrument files containing grids, instructions for working on questions, questions, answer keys, as well as scoring and interpretation guidelines equipped with an excel file to analyze test results. The display of the final EMD-Test questions presented through Google Forms can be seen in Figure 5. Figure 5(a) shows header, tittle, and question details; Figure 5(b) shows question work instructions and student identity; and Figure 5(c) shows question details. Meanwhile, the EMD-Test product in file form can be seen in Figure 6; Figures 6(a) for cover, Figure 6(b) for grid, 6(c) for problem, 6(d) for answer key, 6(e) for scoring and interpretation guidelines, and 6(f) for full product link.



(a) (b) (c)

Figure 5. EMD-test display presented through Google Forms, (a) header, form title, and question identity, (b) instructions for the questions and student identity, and (c) question



(a) (b) (c)

(d) (e) (f)

Figure 6. EMD-Test display in file format (a) cover, (b) grid, (c) problem, (d) answer key, (e) scoring and interpretation guidelines, and (f) full product link

4. CONCLUSION

The EMD-Test which is a diagnostic test instrument for misconceptions in the form of a three-tier multiple choice test presented using a valid and reliable Google Forms platform has been successfully developed. A valid EMD-Test product has been successfully developed because it has obtained a very feasible category based on the results of the average quality score of the validators, which is 3.27; biology teacher at 3.74; and 3.41 students. In addition, through the results of item validation, the final EMD-Test product contains only valid items. The reliable EMD-Test product has been successfully developed because it has obtained a reliability coefficient value of 0.87 for three-level questions.

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REFERENCES

[1] E. Aryani, "Identification of Students' Misconceptions on Salt Hydrolysis Material Using Two-Tier Diagnostic Test Instruments at State Senior High School 4 Wira Bangsa Meulaboh," (in Indonesian), Bachelor Thesis, UIN Ar-Raniry, Indonesia, 2021.

[2] J. Jusniar, E. Effendy, E. Budiasih, and S. Sutrisno, "Developing a Three-Tier Diagnostic Instrument on Chemical Equilibrium (TT-DICE)," *Educación Química*, vol. 31, no. 3, pp. 84–102, Jun. 2020, doi: 10.22201/fq.18708404e.2020.3.72133.

[3] Z. D. Kirbulut and O. Geban, "Using Three-Tier Diagnostic Test to Assess Students' Misconceptions of States of Matter," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 10, no. 5, pp. 509–521, Dec. 2014, doi: 10.12973/eurasia.2014.1128a.

[4] H. Listiani, "Analysis of High School Students' Misconceptions Using Certainty of Response Index (CRI) on Animalia Materials at SMA Negeri 12 Bandar Lampung Academic Year 2016/2017," (in Indonesian), Undergraduate Thesis, UIN Raden Intan Lampung, Indonesia, 2017.

[5] E. Murdani and S. Sumarli, "Identification of Students Misconceptions in School and College on Kinematics," in *Proceedings of the Borneo International Conference on Education and Social Sciences*, SCITEPRESS - Science and Technology Publications, 2018, pp. 75–82. doi: 10.5220/0009016800750082.
[6] A. Q. Pebrianto, A. M. A. Mu'nisa, and Abd. M. Abd. Muis, "Identification of Students' Misconceptions Using the Certainty of Response Index (CRI) Method on Ecosystem Materials for Class XI MIA MAN 1 Jeneponto," (in Indonesian), *Biology Teaching and Learning*, vol. 3, no. 2, pp. 124–131, Jun. 2021, doi: 10.35580/btl.v3i2.19543.
[7] W. M. Purwanti and S. Kuntjoro, "Profile of Ecological Misconceptions Using the Four-Tier Test for Class X High School Students," (in Indonesian), *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, vol. 9, no. 3, pp. 414–421, Sep. 2020, doi: 10.26740/bioedu.v9n3.p414-421.
[8] S. Soeharto, B. Csapó, E. Sarimanah, F. I. Dewi, and T. Sabri, "A Review of Students' Common Misconceptions in Science and Their Diagnostic Assessment Tools," *Jurnal Pendidikan IPA Indonesia*, vol. 8, no. 2, p. 247, 2019, doi: 10.15294/jpii.v8i2.18649.
[9] B. H. Munson, "Ecological Misconceptions," *The Journal of Environmental Education*, vol. 25, no. 4, pp. 30–34, Jul. 1994, doi: 10.1080/00958964.1994.9941962.
[10] M. S. Bal, "Misconceptions of high school students related to the conceptions of absolutism and constitutionalism in history courses," *Educational Research and Reviews*, vol. 6, no. 3, pp. 283–291, 2011.
[11] A. B. Champagne, L. E. Klopfer, and R. F. Gunstone, "Cognitive research and the design of science instruction," *Educational Psychologist*, vol. 17, no. 1, pp. 31–53, Jan. 1982, doi: 10.1080/00461528209529242.
[12] C. Chen, G. Sonnert, P. M. Sadler, D. Sasselov, and C. Fredericks, "The impact of student misconceptions on student persistence in a MOOC," *Journal of Research in Science Teaching*, vol. 57, no. 6, pp. 879–910, Aug. 2020, doi: 10.1002/tea.21616.
[13] H. F. Firman, J. Ratnasari, and S. Windyariani, "Identification of Students' Misconceptions Using the Two-Tier Test Assisted Certainty Of Response Index," (in Indonesian), *BIODIK*, vol. 7, no. 2, pp. 33–44, Jun. 2020, doi: 10.22437/bio.v7i2.12812.
[14] P. W. Hewson and M. G. A'B. Hewson, "An appropriate conception of teaching science: A view from studies of science learning," *Science Education*, vol. 72, no. 5, pp. 597–614, Oct. 1988, doi: 10.1002/sce.3730720506.
[15] L. Fitriah, "Diagnosing Students' Misconceptions on Heat Materials by Using Three-Tier Essays and Open–Ended Test Items," (in Indonesian), *Berkala Ilmiah Pendidikan Fisika*, vol. 5, no. 2, pp. 168–181, Jun. 2017, doi: 10.20527/bipf.v5i2.3007.
[16] A. A. Alwan, "Misconception of heat and temperature Among physics students," *Procedia - Social and Behavioral Sciences*, vol. 12, pp. 600–614, 2011, doi: 10.1016/j.sbspro.2011.02.074.
[17] J. N. Burgoon, M. L. Heddle, and E. Duran, "Re-Examining the Similarities Between Teacher and Student Conceptions About Physical Science," *Journal of Science Teacher Education*, vol. 21, no. 7, pp. 859–872, 2010, doi: 10.1007/s10972-009-9177-0.
[18] F. H. Kusumah, "Diagnosis of Students' Misconceptions on Heat Material Using Three-Tier Test," (in Indonesian), Universitas Pendidikan Indonesia, Indonesia, 2013.
[19] K. Nisa, "Students' Misconceptions on Ecosystem Materials in Class X IPA Madrasah Aliyah Negeri 1 Langkat in the 2018/2019 Academic Year," (in Indonesian), Undergraduate Thesis, Universitas Negeri Medan, Indonesia, 2019.
[20] N. M. Seel, *Encyclopedia of the Sciences of Learning*, 1st ed. Boston, MA: Springer US, 2012. doi: 10.1007/978-1-4419-1428-6.
[21] V. Setyaningrum and W. Sopandi, "Probing 8th Grade Students' Conception about Heat and Temperature Using Three-Tier Test: A Case Study," *Jurnal Pendidikan Fisika Indonesia*, vol. 17, no. 2, pp. 115–125, Nov. 2021, doi: 10.15294/jpfi.v17i2.25272.
[22] L. Ferliyati, T. H. Kurniati, and A. Suryanda, "The Application of Inquiry-Based Interactive Multimedia to minimize Student Misconception on Biotechnology Sucject," *Biosfer: Jurnal Pendidikan Biologi*, vol. 7, no. 1, pp. 17–25, 2014, doi: 10.21009/biosferjpb.7-1.3..
[23] I. Reziana, A. Achmad, and R. R. T. Marpaung, "Identification of Misconceptions of Science Materials for Class VII SMP N 1 Gunung Sugih, Central Lampung," (in Indonesian), *Jurnal Bioterdidik: Wahana Ekspresi Ilmiah*, vol. 5, no. 6, 2017.
[24] G. Rolahnoviza, "Analysis of Students' Misconceptions in Science Subjects at SMPN 4 Penukal Utara, Penukal Abab Regency, Lematang Ilir Pendopo," (in Indonesian), Undergraduate Thesis, UIN Raden Fatah, Indonesia, 2021.
[25] R. Susanti, "Misconception of biology education student of teacher training and education of Sriwijaya University to the concept of photosynthesis and respiration," *Journal of Physics: Conference Series*, vol. 1022, no. 1, p. 012056, May 2018, doi: 10.1088/1742-6596/1022/1/012056.
[26] F. A. Zulfia, H. Susilo, and D. Listyorini, "Virus-bacteria diagnostic test (vbd-test) in identifying biology teacher's misconception," *Biosfer*, vol. 12, no. 2, pp. 144–156, Nov. 2019, doi: 10.21009/biosferjpb.v12n2.144-156.
[27] S. S. Turmiati, A. Arwnif, and R. R. Marpaung, "Identification of Students' Misconceptions in Science Materials for Class VII SMPN 2 Buay Bahuga," (in Indonesian), *Jurnal Bioterdidik: Wahana Espresi Ilmiah*, vol. 54, no. 2, 2017.
[28] I. Yunanda, H. Susilo, and A. Ghofur, "Misconceptions identification on biodiversity and protist using multiple choice open reason (mcor)," *Biosfer*, vol. 12, no. 2, pp. 170–181, Nov. 2019, doi: 10.21009/biosferjpb.v12n2.170-181.
[29] F. Abidah, "Development of Two-Tier Diagnostic Test Instruments in Identifying Misconceptions of Ecological Materials for Class XII High School Students," (in Indonesian), Undergraduate Thesis, UIN Walisongo, Indonesia, 2018.
[30] A. K. Griffiths and B. A. C. Grant, "High school students' understanding of food webs: Identification of a learning hierarchy and related misconceptions," *Journal of Research in Science Teaching*, vol. 22, no. 5, pp. 421–436, 1985, doi: 10.1002/tea.3660220505.
[31] S. Hughes, F. Lyddy, and S. Lambe, "Misconceptions about Psychological Science: A Review," *Psychology Learning & Teaching*, vol. 12, no. 1, pp. 20–31, Mar. 2013, doi: 10.2304/plat.2013.12.1.20.
[32] M. J. Leonard, S. T. Kalinowski, and T. C. Andrews, "Misconceptions Yesterday, Today, and Tomorrow," *CBE—Life Sciences Education*, vol. 13, no. 2, pp. 179–186, Jun. 2014, doi: 10.1187/cbe.13-12-0244.
[33] B. W. Miller and W. F. Brewer, "Misconceptions of Astronomical Distances," *International Journal of Science Education*, vol. 32, no. 12, pp. 1549–1560, Aug. 2010, doi: 10.1080/09500690903144099.
[34] S. Mubarak, E. Susilaningsih, and E. Cahyono, "Development of a three tier multiple choice diagnostic test to identify misconceptions of class XI students," (in Indonesian), *Journal of Innovative Science Education*, vol. 5, no. 2, pp. 101–110, 2016.
[35] S. Hasan, D. Bagayoko, and E. L. Kelley, "Misconceptions and the Certainty of Response Index (CRI)," *Physics Education*, vol. 34, no. 5, pp. 294–299, Sep. 1999, doi: 10.1088/0031-9120/34/5/304.
[36] L. Nurhidayah, R. Riandi, and R. Solihat, "Identifying high school students' misconceptions on the topic of ecosystem," (in Indonesian), *Assimilation: Indonesian Journal of Biology Education*, vol. 3, no. 1, p. 12, 2020, doi: 10.17509/aijbe.v3i1.23303.
[37] A. D. Sekartaji, "Development of Format Tests that Serve as Diagnostic Tests of Learning Difficulties Based on Moodle on Physics Materials for Class X Senior High School Even Semesters," (in Indonesian), Undergraduate Thesis, Universitas Negeri Jakarta, Indonesia, 2021.
[38] R. Ramadhani, R. Umam, A. Abdurrahman, and M. Syazali, "The Effect of Flipped-Problem Based Learning Model Integrated With LMS-Google Classroom for Senior High School Students," *Journal for the Education of Gifted Young Scientists*, vol. 7, no. 2, pp. 137–158, Jun. 2019, doi: 10.17478/jegys.548350.

[39] A. Hasanah, "Development of Google Forms-Based Misconception Instruments on Business and Energy Materials Using the Four Tier Test," (in Indonesian), Undergraduate Thesis, Universitas Islam Negeri Raden Intan, Indonesia, 2020.
[40] T. Mardiana and A. W. Purnanto, "Google Form as an Alternative for Making Evaluation Questions (in Indonesian)," in *The 6th University Research Colloquium 2017*, Magelang: URECOL, 2017, pp. 183–188.
[41] N. Sari and E. L. E. Ahsani, "Implementation of Google Form-based learning evaluation during the pandemic period for elementary/MI students," (in Indonesian), *Terampil: Jurnal Pendidikan dan Pembelajaran Dasar*, vol. 7, no. 2, pp. 107–118, 2020.
[42] U. Kanli, "A Study on Identifying the Misconceptions of Pre-service and In-service Teachers about Basic Astronomy Concepts," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 10, no. 5, 2014, doi: 10.12973/eurasia.2014.1120a.
[43] H. Peşman and A. Eryılmaz, "Development of a Three-Tier Test to Assess Misconceptions About Simple Electric Circuits," *The Journal of Educational Research*, vol. 103, no. 3, pp. 208–222, Feb. 2010, doi: 10.1080/00220670903383002.
[44] H. F. Marpaung, A. Supriadi, and T. Nugraha, "Development of Attitude Instrument Assessment in Physical Education Learning for Tanjung Balai, Islamic School," in *Proceedings of the 1st Unimed International Conference on Sport Science (UnICoSS 2019)*, Paris, France: Atlantis Press, 2020, pp. 182–184. doi: 10.2991/ahsr.k.200305.051.
[45] S. Thiagarajan, D. S. Semmel, and M. I. Semmel, *Instructional development for training teachers of exceptional children: a Sourcebook*. Bloomington, Indiana: ERIC, 1974.
[46] K. Khamid, "Development of Computer Supported Creative Thinking Test (CSCeT-Test) Regarding Global Warming Materials for High School/MA Students," (in Indonesian), *SPEKTRA: Jurnal Kajian Pendidikan Sains*, vol. 5, no. 1, p. 44, May 2019, doi: 10.32699/spektra.v5i1.67.
[47] P. Lestari, R. H. Ristanto, and M. Miarsyah, "Metacognitive and Conceptual Understanding of Pteridophytes: Development and Validity Testing of an integrated Assessment Tool," *Indonesian Journal of Biology Education*, vol. 2, no. 1, pp. 15–24, Apr. 2019, doi: 10.31002/ijobe.v2i1.1225.
[48] S. Aisyah, "Development of Four Tier Shape Diagnostic Test Instruments on Mechanical Wave Materials and the Doppler Effect," (in Indonesian), Undergraduate Thesis, Universitas Pendidikan Indonesia, Indonesia, 2018.
[49] A. A. Martinah, V. Mubarok, M. Miarsyah, and R. H. Ristanto, "Development of Contextual-Based Science Literacy Test Instruments on Environmental Pollution Materials," (in Indonesian), *Bioedusiana: Jurnal Pendidikan Biologi*, vol. 6, no. 2, pp. 192–218, Jan. 2022, doi: 10.37058/bioed.v6i2.3251.
[50] T. G. Ratumanan and T. Laurens, *Evaluation of Learning Outcomes at the Education Unit Level*. Surabaya: UNESA University Press (in Indonesian), 2011.
[51] S. Arikunto, *Research Procedure A Practice Approach Revised Edition*. Jakarta: Rineka Cipta (in Indonesian), 2010.
[52] A. Rusilowati, *Assessment Instrument Development*. Semarang: UNNES Press (in Indonesian), 2014.
[53] H. O. Arslan, C. Cigdemoglu, and C. Moseley, "A Three-Tier Diagnostic Test to Assess Pre-Service Teachers' Misconceptions about Global Warming, Greenhouse Effect, Ozone Layer Depletion, and Acid Rain," *International Journal of Science Education*, vol. 34, no. 11, pp. 1667–1686, Jul. 2012, doi: 10.1080/09500693.2012.680618.
[54] R. Gusmalia, "The Use of Concept Map Assessment to Analyze Students' Misconceptions on Ecosystem Materials for Class X SMA Al-Azhar 3 Bandar Lampung," (in Indonesian), Undergraduate Thesis, UIN Raden Intan, Lampung, 2018.
[55] M. W. Lidi, M. F. Mei, and M. T. S. Wondo, "Identification of Mathematics Education Students' Misconceptions Using the CRI (Certainty of Response Index) Method in Ecology Materials in Biology Courses (in Indonesian)," in *Seminar Nasional Pendidikan Dasar PGSD Uniflor*, Ende: INA-Rxiv, 2017, pp. 159–166.
[56] T. A. Mustakim, Z. Zulfiani, and Y. Herlanti, "Identification of Students' Misconceptions Using The Certainty of Response Index (CRI) Method on The Concepts of Photosynthesis and Plant Respiration," (in Indonesian), *EDUSAINS*, vol. 6, no. 2, pp. 145–152, Mar. 2015, doi: 10.15408/es.v6i2.1117.
[57] N. W. N. Sari and S. Sunyono, "Development of The Three Tier Diagnostic Test Based 'Higher Order Thinking Skills' Instrument," *Dinamika Jurnal Ilmiah Pendidikan Dasar*, vol. 11, no. 2, pp. 86–93, 2019, doi: 10.30595/dinamika.v11i2.5053.
[58] D. Septiana, Z. Zulfiani, and M. F. Noor, "Identification of Students' Misconceptions on The Concept of Archaebacteria and Eubacteria Using Two-Tier Multiple Choice," (in Indonesian), *EDUSAINS*, vol. 6, no. 2, pp. 191–200, Mar. 2015, doi: 10.15408/es.v6i2.1151.
[59] K. Fadila, "Development of Three Tier Diagnostic Tests to Identify Students' Misconceptions on The Interaction of Living Things with The Environment," (in Indonesian), Master Thesis, Universitas Pendidikan Indonesia, Indonesia, 2021.
[60] F. Haslam and D. F. Treagust, "Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument," *Journal of Biological Education*, vol. 21, no. 3, pp. 203–211, Sep. 1987, doi: 10.1080/00219266.1987.9654897.
[61] S. Ulfa, "The Effect of Word Search Puzzle Game Media on the Vocabulary of Scientific Vocabulary and Biology Terms for Class VIII Students of MTs Al-Khairiyah Jambi City," (in Indonesian), Universitas Islam Negeri Sulthan Thaha Syaifudin Jambi, Indonesia, 2018.
[62] J. Butler, G. Mooney Simmie, and A. O'Grady, "An investigation into the prevalence of ecological misconceptions in upper secondary students and implications for pre-service teacher education," *European Journal of Teacher Education*, vol. 38, no. 3, pp. 300–319, Jul. 2015, doi: 10.1080/02619768.2014.943394.
[63] D. Diella and R. Ardiansyah, "Development of Four-tier Diagnostic Test Ecosystem Concept: Instrument Validity and Reliability," (in Indonesian), *BIODIK*, vol. 6, no. 1, pp. 1–11, Mar. 2020, doi: 10.22437/bio.v6i1.8093.
[64] E. O. Adeniyi, "Misconceptions of selected ecological concepts held by some Nigerian students," *Journal of Biological Education*, vol. 19, no. 4, pp. 311–316, Dec. 1985, doi: 10.1080/00219266.1985.9654758.
[65] S. S. Putri and L. Rusyati, "Analyzing the science misconception in mastery concept of ecosystem topic at senior high school," *Journal of Physics: Conference Series*, vol. 1806, no. 1, p. 012125, Mar. 2021, doi: 10.1088/1742-6596/1806/1/012125.
[66] S. Margalita, F. Rachmadiarti, and M. S. Prastiwi, "Analysis of The Highest Misconceptions of Ecological Material in High School Students," (in Indonesian), *BIOEDU*, vol. 4, no. 3, pp. 996–1001, 2015.
[67] J. Fries-Gaither, "Common Misconceptions About States and Changes of Matter and the Water Cycle," *The Ohio State University*, 2008. [Online]. Available: https://beyondpenguins.ehe.osu.edu/issue/water-ice-and-snow/common-misconceptions-about-states-and-changes-of-matter-and-the-water-cycle.
[68] O. Ben-zvi-Assarf and N. Orion, "A Study of Junior High Students' Perceptions of the Water Cycle," *Journal of Geoscience Education*, vol. 53, no. 4, pp. 366–373, Sep. 2005, doi: 10.5408/1089-9995-53.4.366.
[69] Irnaningtyas, *Biology for first-year of senior high school*. Jakarta: Erlangga (in Indonesian), 2013.
[70] O. Cardak, "Science Students' Misconceptions of the Water Cycle According to their Drawings," *Journal of Applied Sciences*, vol. 9, no. 5, pp. 865–873, Feb. 2009, doi: 10.3923/jas.2009.865.873.

[71] K. Kornei, "Many Water Cycle Diagrams Promote Misconceptions," *EOS Science News*, 2019. [Online]. Available: https://eos.org/articles/many-water-cycle-diagrams-promote-misconceptions.
[72] J. Pragle, "Alternative Conceptions," *The Review: A Journal of Undergraduate Student Research*, vol. 12, pp. 37–42, 2010, [Online]. Available: https://fisherpub.sjf.edu/ur/vol12/iss1/10/.
[73] E. Ural, O. Ercan, and K. Bilen, "Pre-Service Science Teachers' Misconceptions of Carbon Cycle and Global Warming," *Scientific Educational Studies*, vol. 1, no. 1, pp. 1–17, 2017.
[74] A. Baihaki, "Development of a three-level diagnostic test to identify students' misconceptions on Lines and Angles Material," (in Indonesian), Undergraduate Thesis, UIN Sunan Ampel, Surabaya, 2020.
[75] Y. Kutluay, "Diagnosis of Eleventh Grade Students' Misconceptions About Geometric Optic by A Three-Tier Test," Master Thesis, Middle East Technical University, Ankara, 2005.
[76] D. F. Treagust, "Development and use of diagnostic tests to evaluate students' misconceptions in science," *International Journal of Science Education*, vol. 10, no. 2, pp. 159–169, Apr. 1988, doi: 10.1080/0950069880100204.
[77] H. H. Batubara, "The Use of Google Forms as a Tool for Assessing Lecturer Performance at the PGMI Uniska Study Program Muhammad Arsyad Al Banjari," (in Indonesian), *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, vol. 8, no. 1, pp. 39–50, 2016.
[78] A. Cetin-Dindar and O. Geban, "Development of a three-tier test to assess high school students' understanding of acids and bases," *Procedia - Social and Behavioral Sciences*, vol. 15, pp. 600–604, 2011, doi: 10.1016/j.sbspro.2011.03.147.
[79] N. Aurora and Atmazaki, 'Use of Conjunctions as An Element of Cohesion in The Main News of The Singgalang Daily Newspaper, May—June 2020 Edition," (in Indonesian), *Jurnal Bahasa dan Sastra Indonesia*, vol. 9, no. 4, pp 47–54, 2020, [Online]. Available: https://ejournal.unp.ac.id/index.php/pbs/article/viewFile/110727/104222.
[80] ST. M. Rullu, "Slang in The EFL Classroom Interaction", *Jurnal ADHUM*, vol. 8, no. 2, pp. 7–13, 2018, [Online]. Available: https://jurnal.ummi.ac.id/index.php/JAD/article/view/258.
[81] A. A. Rezigalla, "Item Analysis: Concept and Application," in *Medical Education for the 21st Century*, IntechOpen, 2022. doi: 10.5772/intechopen.100138.
[82] B. K. Bayrak, "Using Two-Tier Test to Identify Primary Students' Conceptual Understanding and Alternative Conceptions in Acid Base," *Mevlana International Journal of Education*, vol. 3, no. 2, pp. 19–26, Aug. 2013, doi: 10.13054/mije.13.21.3.2.
[83] D. A. Syahrul and W. Setyarsih, "Identification of Misconceptions and Causes of Students' Misconceptions with Three-tier Diagnostic Test on Rotational Dynamics Materials" (in Indonesian), *Jurnal Inovasi Pendidikan FIsika (JIPF)*, vol. 4, no. 3, pp. 67–70, 2015.

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