Analysis of student's misconceptions on the material of the immune system using a three-tier diagnostic test

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Article Info	ABSTRACT
	Distance learning and face-to-face learning at Senior High School of 3 Magelang makes it difficult for students to understand the concept of the system the immune system so that it triggers misconceptions in students. This study aims to analyze students' misconceptions about the material on the immune system at Senior High School of 3 Magelang. The research method is uses qualitative methods to be able to explain more deeply about students' misconceptions. Twenty-five multiple-choice questions in three tiers are given to determine the distribution of students' conceptions. The analysis showed that 64,16% of misconceptions were found in the concept of definition and function of the immune system, followed by the concept of antigens and antibodies with 58.7%, the concept of the mechanism of the immune system with 56.74% and disorders of the immune system with 41.4%. Based on the interviews and questionnaires, the factors that cause misconceptions come from the teacher's teaching methods with less effective, text-books and the lack of student activity, and learning media that have not been varied. So, it can be concluded that students' misconceptions on the material of the immune system are still found with a high level of misconceptions.

INTRODUCTION

One of innovation in the learning process caused by the Covid-19 is by conducting online learning or distance learning. Learning that is carried out online makes some students feel that they do not understand some difficult subjects independently, including biology. This gives rise to student misunderstandings with material taught independently and learning outcomes do not meet completeness with a low average score and do not meet predetermined indicators (Maulana, 2020).

Research (Yudhistira & Murdiani, 2020) shows that distance learning causes the quality of student learning to decrease either from motivation or student learning outcomes. The lack of student activity in discussion sessions is also a factor in distance learning that is not optimal. (Pasaribu & Listiani, 2021) explained that students were less active in implementing distance learning. When the teacher finished explaining and asking questions about the material, many students did not immediately answer so it took a long time for students to be able to answer simple questions. Often students also turn off the camera and microphone to avoid being pointed at by the teacher. Even when the teacher provides opportunities for students in the discussion session, only a few students are active in the discussion, the rest just listen and do not give personal opinions.

Based on the existing causes of misconceptions, during distance learning the most common causes of misconceptions are due to teaching methods and use of tools. In research (Sakidin & Hamidah, 2020) explains that during distance learning, teachers and students face a lack of mastery in the use of information technology such as smartphones, laptops and learning applications, limited presentation of learning so that learning is less effective, concentration is not optimal. causes students to fail to understand or have misconceptions about the learning material.

Apart from distance learning problems, limited face-to-face learning is also not optimal for increasing student understanding. Reducing the time from sixty minutes to thirty minutes per onehour lesson and the time span of students at school which is only from 07.00 WIB to 09.00 WIB does not make students feel optimal in learning. Based on the description of the facts above, there are many possibilities for students who experience misconceptions while studying biology in distance learning and face-to-face learning. According to several studies conducted (Raida, 2018) which stated that the immune system material was the second most difficult material based on the results of a student and teacher survey for the even semester XI class material.

Each subject has its own characteristics and concepts, including biology, which has a continuous concept, so that if one concept cannot be understood correctly, the next concept will also be difficult for students to understand (Suparno, 2013). This results in students experiencing conceptual misunderstandings or misconceptions. Misconception is a person's conception that is not in accordance with scientific conceptions recognized by experts (Konawe, 2019).

One of the misconception analysis techniques is the Three Tier diagnostic test which was previously developed by Haki Pesman and Ali Eryilmaz research. The three-tier diagnostic test has more advantages than the one-tier test and two-tier test, because it is able to distinguish students who lack knowledge based on students' beliefs when answering questions on one tier and two tier (Pesman & Eryilmaz, 2010) and (Gurel, Eryilmaz, & McDermott, 2015). Thus, this level of belief also affects the calculation of misconceptions and concepts mastered by students. Based on the background, analysis of the problems, and solutions offered to conduct research with the formulation of the problem "How are students' misconceptions about the material on the immune system using the Three Tier diagnostic test at Senior High School of 3 Magelang?" and the purpose of this research was to analyze students' misconceptions about the material on the immune system at Senior High School of 3 Magelang.

RESEARCH METHODS
Research Design

This research is using descriptive qualitative method which seeks to analyze the misconceptions that occur in the material of the immune system. Qualitative method is a method that produces descriptive data in the form of written or spoken words from people and observed behavior. The type of qualitative descriptive research in this study aims to describe students' misconceptions based in the three tier diagnostic test results and interview data are used to be able to analyze these misconceptions.

Population and Samples

The population in this study were all students of class XI MIPA Senior High School of 3 Magelang, totaling 179 students. Sampling was taken using simple random sampling technique. Every XI MIPA student at Senior High School of 3 Magelang has the same opportunity to be a sample or to represent the population. Researchers took 10 students in each class and a sample of 51 students of class XI MIPA Senior High School of 3 Magelang.

Instruments

The focus of this research is analysis students misconceptions in solving questions about the immune system. The research instruments are the the form of the test questions diagnostics, questionnaires and interviews with teachers. The diagnostic test questions consist of 25 questions which includes material on the understanding of the immune system, antigens and antibodies, mechanisms of immune system and immune system disorders. Test questions are also made to find misconceptions.

Procedures

The stages carried out in this research are: (1) Determine the problems that occur in Senior High School of 3 Magelang, the problem of this research is students's misconceptions. (2) Search and collect research references that related to the problem to be researched. (3) Conduct research by giving tests that have been tested for validity and reliability to students. (4) Conduct interview with teachers of Senior High School of 3 Magelang and questionnaire that has been test for validity and reliability will be givem to the teachers as a respondent to obtain supporting data. (5) Analyzing the research data that have been obtained in ordeer to the conclusions can be drawn taken from the research meta-analysis conducted.

Data Analysis

The data analysis technique used in students misconceptions on the material of the immune ystem is to analyze the research data descriptively. Then according to three-tier diagnostic test, the assessment will be analyzed in three stages. (1) The first stage of students' multiple-choice questions is divided into true and false criteria. Each student who answers correctly or incorrectly is presented in into Table 1. (2) The second stage, after grouping students in the second stage is contains the answers to the reasons for the first answer that the students have chosen. If in the first stage the student answers correctly while the student answers incorrectly in the second stage, then the student is classified into a misconception and if the student answers correctly and in the second stage the student's answer is correct then the student is classified into understanding the concept or guessing (lucky guess). In the second stage, the criteria still cannot ensure students are classified into misconceptions or other criteria. (3) In the third stage, it contains a choice of students' beliefs about the first and second answers that have been chosen. This thrid stage will analyze power and classify students into understanding concepts, not understanding concepts and misconceptions or guessing. The data were analyzed using a combination answer analysis technique, as shown in Table 1 adopted by Arslan, Cigdemoglu, and Moseley (2012).

After looking at the categories in table 1, to analyze the percentage of students who have misconceptions and students who do not know the concept, the percentage technique used is as follows:

$$P = \frac{a}{Ja} x 100^{\%}$$

Information:

P = Percentage of the number of students who understand the concept, do not understand the concept and misconceptions

a = Number of students who understand the concept, do not understand the concept, misconception

Ja = Total number of students

Table 1. Classification of Misconceptions

First tier	Second tier	Third tier	Categories
Correct	Correct	Certain	Scientific knowledge
Correct	Incorrect	Certain	Misconception (false positive)
Incorrect	Correct	Certain	Misconception (false negative)
Incorrect	Incorrect	Certain	Misconception
Correct	Correct	Uncertain	Lucky guess, lack of confidence
Correct	Incorrect	Uncertain	Lack of knowledge
Inccorect	Correct	Uncertain	Lack of knowledge
Incorrect	Incorrect	Uncertain	Lack of knowledge

After classification student test results and calculating the percentage of students who experience misconceptions, then the criteria for misconceptions is according to Table 2.

Table 2. Criteria of Misconception

Percentage of Misconceptions	Misconceptions Criteria
0 < Misconceptions ≤ 30%	Low
30 < Misconceptions ≤ 70%	Medium
70 < Misconceptions ≤ 100%	High

Source: (Kurniawan & Suhandi, 2015)

RESULT

In the material of the immune system, there are four concepts studied; the definition and function of immune system, antigens and antibodies, mechanisms of the immune system and disorders of the immune system. The result of students misconceptions of four concepts are presented in Figure 1.
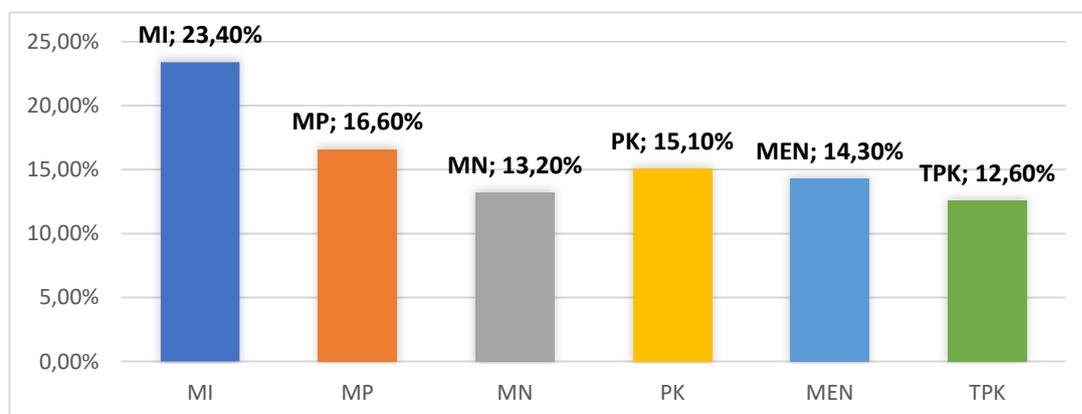

Figure 1. Diagram of the category of misconceptions

Information:
MI   = Misconception
MP   = Misconception (False Positive)
MN   = Misconception (False Negative)
MEN = Lucky Guess
TPK   = Lack of Knowledge

Based on figure 1, the results of students' conceptions showed that the misconception category (MI) had a mean score of 23.4%, the positive misconception category (MP) was 16.6%, and the negative misconceptions category (MN) was 13.2% so for the students' misconception category had an average of 53.28%. Besides that, understanding the concept (PK) with a percentage of 15.1%, the guessing category (MEN) with the acquisition of 14.3%, and the category of not understanding the concept with a percentage of 12.6%. If the percentage of students experiencing misconceptions was less than equal to 30%. It can be categorized into common misconceptions, whereas if the percentage of students experiencing misconceptions was less than 70%, it could be classified into moderate misconceptions. If the percentage of students experiencing misconceptions was between 70-100%, it could be categorized as a high misconception.

Based on the calculations for each concept of immune system material, the highest misconception was at the beginning of the concept, namely the concept of understanding and function of the immune system with a total of 64.16%, followed by the concept of antigen and antibody by 58.7%. In comparison, the concept of the immune system mechanism obtained a percentage of 56.74%, and misconceptions on the concept of the immune system disorders were the lowest misconception with a percentage of 41.4%. The distribution of items in each misconception can be seen in Table 3.

Table 3. Results of Misconceptions based on the Concept of the Immune System

Concept	Question Point Number	Total Item Question	$\bar{x}$ (%)
Definition and function of the immune system	1, 2, 3, 4, 25	5	64,16
Antigens and Antibodies	6, 19, 20, 21, 23	5	58,7
Mechanism cencept of the immune system	5, 7, 8, 9, 10, 11, 16, 17, 22, 24	10	56,74
Disorders of the immune system	12, 13, 14, 15, 18	5	41,4

DISCUSSION

This research aims to determine students misconceptions on the material of the immune system using a three-tier diagnostic test at Senior High School of 3 Magelang. Based on the result, the highest misconceptions were found in items 2, 6, 7, 8, 9, 10, 20, and 25. Items 2 and 25 had the same concept, namely the definition and function of the immune system, with different types of questions. Item 2 had a question indicator examining the role of B cells and T cells for Covid-19 patients, and item 25 with a question indicator explaining the production of antibodies by B cells. Questions 6 and 20 were included in the antigen and antibody concept with question indicators in item 6 was to distinguish immunoglobulins based on their characteristics and in item 20 with question indicators explaining the agglutination process.

High misconceptions were also found in the machine concept of the immune system and were found in items 7, 8, 9, and 10. Item 7 had an indicator of the cause and effect of smallpox and measles. Item 8 had an indicator of distinguishing between specific and non-specific defenses, item 9 with an indicator of special substances for biochemical defense, and item 10 with an indicator of the role of antimicrobial substances naturally contained in tears, urine, and sweat.

Medium level misconceptions were found in items 1, 3, 4, 5, 12, 13, 15, 16, 17, 18, 19, 21, 22, 23, 24. Items 1, 3, and 4 had the same concept, namely understanding, and the immune system. Item 1 had an indicator about the understanding of the immune system, item 3 had an indicator about the characteristics of the specific immune system, and item 4 had an indicator about the components of the specific immune system. The antigen and antibody concepts were also found in items 19, 21, and 23. Item 19 had an indicator for the types of immunoglobulins. Item 21 had an indicator for an antibody-producing organ. Item 23 indicated the immune system's role when an antigen infects the body.

The mechanism concept of the immune system was only found in questions 5, 16, and 17. Item 5 indicates the type of immune cell when pus was formed. Item 16 with an indicator of the response of immune system cells to the presence of antigens, and item 17 with indicators about malaria prevention. The concept of immune system disorders was also found in items 12, 13, 15, and 18. Question 12 had the concept of the cause of autoimmune disease, and item 13 had indicators for the effects of AIDS on the immune system. Item 15 had indicators about diseases related to the immune system based on symptoms and symptoms. Item 18 with an indicator of hepatitis A disease. Low-level misconceptions were found in items 11 and 14, item 11 had a question indicator, and item 14 had an indicator of immune disorders related to IgE.

In formal education, misconceptions can be formed when students want to try to form knowledge by translating new experiences into initial concepts. The initial concepts before learning are called preconceptions. The preconceptions that students bring to class are not the same. Some are in harmony with science, but some are not in harmony with what the school provides. Students whose preconceptions are correct will easily absorb the material. On the contrary, those who are wrong will face difficulty. The concept of understanding and functioning of the immune system, antigens and antibodies, and the mechanism of the immune system is included in the material that requires deep scientific reasoning, and many scientific words are still unfamiliar.

In (Hamsyah, Luzyawati, & Yuliana, 013) explained that this concept is complex because understanding the processes in the organ system cannot be observed directly, so if students misunderstand the concept will have the opportunity to lead to misconceptions. Based on the research results, it can be seen that the conceptual understanding of students in Senior High School of 3 Magelang on the material of the immune system was still relatively low. This can be seen from the fact that the largest percentage was in the initial concept, namely the concept of understanding and functioning of the immune system. This showed that the preconceptions brought by students were not the same as the concepts that should be. However, because there was no identification of the wrong concept, students assumed that their preconceptions were correct.

Research (Kholifah, Kusumaningrum, Rinanto, Ramli, & Marjono, 2014) found misconceptions in the immune system material on the concept of specific and non-specific body defense mechanisms at Senior High School of 6 Surakarta, the concept of understanding the immune system and antibodies and antigens in Senior High School of Muhammadiyah 1 Karanganyar. Students could not understand the correct mechanism concept for forming antibodies for body defense, and scientific words that were still unfamiliar to students caused students to have difficulty remembering scientific words and creating misconceptions.

The following research by (Hadiyanti & Widodo, 2015) showed that the biggest misconception was in the sub-materials, namely the parts of the immune system and the working

mechanism of the immune system (48.5%). The explanation supported this that students had not been able to clearly distinguish the differences between the parts of the immune system only from the pictures presented by the teacher during the lesson. Students also had not been able to clearly distinguish between the action mechanism of the natural immune system obtained and artificial for the long term in the human body. So this showed that the material on the immune system was one of the difficult and abstract materials, so the students faced difficulty imagining the concepts in it.

Factors that cause misconceptions based on interviews and questionnaires were divided into internal factors, namely the students themselves. During the process of learning biology, only a few students were active in class discussions, and students who took distance-learning were not active in discussions. This was what makes misconceptions still found in the immune system material. Students who did not know the concept and students who experienced misconceptions could not be identified directly if students did not ask questions about concepts that had not been understood in-depth (Wibowo, 2916). This was also supported in research (Pasaribu & Listiani, 2021), explaining that the lack of student activity in discussion sessions was also a factor of distance learning that was not optimal. Learning that was not optimal was also one of the causes of students' misconceptions (Pawicara & Conilie, 2020).

The misconceptions in this research were also caused by external factors, namely the teacher's teaching methods, and textbooks. Teachers still used the lecture method during the learning process, so the students were less active in the learning process. However, due to the limited learning time, the teacher did not in-depth teach the material to the students. The teacher focused more on the students on practice questions as a deepening of the material. As a result, misconceptions were found in almost every class XI biology material. The teacher admitted that distance learning and face-to-face learning were still unstable (Yuliati, 2017). Following the developments of Covid-19, the teacher left much material behind and needed further exploration to avoid misconceptions among students.

With the material provided by the teacher and through the use of the lecture method was difficult to know whether all students had understood the material. This is supported by the theory (Sanjaya, 2011), which states that the material that students can master as a result of the lecture will be limited to what is mastered by the teacher because what the teacher gives is what she/he masters, so what is mastered by students will depend on what the teacher is doing controlled by the teacher. Through the lecture method, it is not easy to know whether all students have understood what is being explained or not (Prahatiningtia, 2020).

In addition to the teacher's teaching methods, textbooks which were the main source of biology material, were also one of the causes of misconceptions because worksheets were rarely used during the learning process. LKS generally increases effectiveness during learning (Ambarwati, 2021). Worksheets were arranged systematically and contained sheets of less thickness than textbooks. According to interviews with teachers, worksheets were rarely used during the learning process. It was only used to give students daily assignments and was not used in any biology material. This was also a factor in misconceptions because the text teaching materials used were only from textbooks and indicated a lack of textbooks for students.

Learning media that have not been varied can also cause misconceptions. After conducting interviews, the teacher explained that learning media was only through power points and sometimes provided learning videos on certain materials. Interesting learning videos in Indonesian on immune system material were limited; generally, interesting learning videos were still widely available in English. Materials on the immune system require visualization or images that clarify the material and can be used by students in carrying out teaching and learning activities in the classroom or outside the classroom. (Kurniawan R. D. & Sulistiowati, 2015).

Visualizations contained in learning materials, media, or resources also contribute to students' misconceptions about biology. If there is no visualization or the visualization of the material is not clear, it will make it difficult for students to learn biology (Ozcan, Ozgur, Kat, & Elgun, 2013). There are many learning media that teachers can use to maximize learning. One of them is interactive multimedia based on discovery learning with a virtual laboratory that allows students to gain experience and conduct experiments to find their concepts (Sari, Gunawan, & Harjono, 2016). Similar research has been conducted previously by (Suhandi, Sinaga, Kaniawati, & Suhendi, 2009) and (Suniati, Sadia, & Suhandana, 2013) that the use of virtual simulation media can increase the effectiveness of the conceptual learning approach, increasing concept understanding and minimizing the number of misconceptions.

CONCLUSION

Based on the research results, The practical implications of this research can be a reference for teachers in designing appropriate learning to facilitate students in understanding the concept so that misconceptions are not rediscovered on biological material. Teachers can adjust teaching methods that appropriate in the process of face-to-face learning and distance learning. mMisconceptions of students at Senior High School of 3 Magelang on the material of the immune system were evenly found in every concept in the material of the immune system. Misconceptions occur in the concept of the definition and function of the immune system, the concept of antigens and antibodies, the concept of the mechanism of the immune system, and the concept of the immune system. The highest misconceptions are found in the concept of definition and function of the immune system, with a percentage of 64,16%. The lowest misconception is in the concept of immune system disorders, with a percentage of 41,4%. The factors that cause misconceptions in students are the characteristics of the immune system material, the use of the teaching method as a teaching method, teaching resources, and learning media that have not been varied.

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