Plant-Animal Tissue Diagnostic Test (PATD-Test) to identify students' misconceptions in biology

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Abstract. Plant and animal tissue material is an important concept to understand because besides dealing with the next material, it becomes the basis for the application of technology in modern biology such as stem cells and plant tissue culture. This study aims to identify students' misconceptions about plant and animal tissue topics in biology. Plant-Animal Tissue Diagnostic Test (PATD-Test) has been valid and reliable consisting of three-tier, including multiple-choice questions with five answer options, choice of reasons, and confidence in the answers chosen for each item. Participants in this study were 758 high school students. PATD-Test results showed that 27.20% of students had misconceptions in plant tissue material and 23.90% in animal tissue. The highest percentage of misconceptions occurs in indicators structure-functions of parenchyma, with a percentage of 48.15%. As for animal tissue, the highest misconception is shown in the indicator structure-function of squamous epithelium with a percentage of 35.88% 41.69%. Furthermore, PATD-Test can be developed to diagnose misconceptions on a broad range with more comprehensive sub-concepts and accompanied by an analysis of misconception factors, one of which is in high school biology textbooks.

1. Introduction
Learning in formal schools as well as daily experiences make students learn about their surroundings. Students often record what is observed and experienced in their daily lives and begin to construct knowledge based on the student's perspective [1]. Knowledge built on the experience of students is often incompatible with scientific knowledge [2]. The incompatibility of students' knowledge with scientific concepts is called a misconception [3].

The results of the students' interpretation of what they observe can be inaccurate, causing misconceptions. The emergence of misconceptions in students is due to the limitations of the students in sorting out the idea in his mind with the scientific concept of matter [4]. The misconception becomes important in learning science because when students have misconceptions that can hinder developing the right idea and further learning considering the concept in science major biology is interrelated [5].

There have been many studies that examine misconceptions in students where the most common causes are students, textbooks, and teachers [6,7]. Misconceptions from students such as initial conception, associative and humanistic thinking, reason construction incomplete, inappropriate intuition, student cognitive development, academic ability, and student interest [8]. Misconceptions that come from textbooks occur because book writers sometimes tend to write using terms that can lead to different perceptions [9]. Furthermore, the cause of teacher misconceptions based on previous research states that the tendency of teachers to think intuitively and the existence of misconceptions
from teachers can be transferred to students [10]. Intuitive thinking is a cognitive process that puts forward feelings and perceptions so that it will be difficult to find the correct answer when you get a concept or a difficult question [11].

Based on the preliminary study by giving a questionnaire to the teacher, it is known that two of the materials that are difficult to understand are the topic of plant tissue and animal tissue. The topic of plant and animal tissue is considered difficult because of the abstract nature of matter. The material is abstract because it is difficult to visualize directly so it requires the help of tools such as a microscope [12]. Several related studies that have been carried out previously include misconceptions on photosynthesis, transpiration, structure and function of the cells [13,14]. The misconceptions are certainly important to immediately known by the teacher because the tasks of the teacher are to guide students to the concept of the right. If the teacher does not seek to improve the concept, then nothing can change [15].

Efforts to detect misconceptions can use various diagnostic instruments. One of the diagnostic instruments for identifying misconceptions is a three-tier [16]. Instrument diagnostics three-tier is considered to have the accuracy that is better in identifying the occurrence of misconceptions in the sample because the instrument that can detect the lack of a percentage of knowledge through the level of trust. It helps users of instruments to determine the percentage of misconceptions and lack of knowledge [17,18]. From the explanation above, this study aims to identify students' misconceptions in biology.

2. Method

2.1 Participants
The research was carried out at twelve high schools in East Java covering Kediri, Lamongan, Malang, and Trenggalek regencies. Each school took a sample of 2 classes so that the total sample obtained was 758 students. The test was given after the students had finished receiving the learning material on plant and animal tissue. Students were given ninety minutes to answer the question in diagnostic test.

2.2 Procedure
The procedure was carried out by adapting Treagust research stages. Detailed research stages are as follows.

2.2.1 defines content
This stage is carried out by determining the boundaries of the concept of plant and animal tissue material to be identified. Concept determination is carried out based on Basic Competency standards. The concepts compiled refer to relevant literature and are presented in the form of a concept map. The concept map that has been prepared is then validated by experts. The concept that has been prepared is a framework for making an open-ended test grid.

2.2.2 collect descriptions of student's misconception
Students' misconceptions were collected through an open-ended test. An open-ended test was given to 117 students to obtain information on their understanding of the content of plant and animal tissue material. The open-ended form of the test is a multiple-choice question with five answer options accompanied by an open column of reasons for the answers that have been selected. The open-ended test that has been applied has passed the validation of the material experts and assessment experts. Test open-ended compiled also considers the results of previous studies related to the concept of matter much going on misconceptions. The test results open-ended form the basis for preparing a two-tier before developing diagnostic tests three-tier that in this study referred to as the Plant-Animal Tissue Diagnostic Test (PATD-Test).
2.2.3 developing the Plant-Animal Tissue Diagnostic Test (PATD-Test)

PATD-Test was developed which contains three levels, namely the third tier involving the level of confidence (whether or not sure) of the students on the answers that have been chosen in both the first and second tier. The examples of PATD-Test are shown in Table 1. The diagnostic test instrument framework is arranged in the form of a grid to illustrate that the concepts presented in the test items are proportional. Furthermore, the diagnostic test is validated by material experts and assessment experts to measure its validity. In additional, a limited scale trial was carried out on 126 127 students to measure the empirical validity of the items.

Table 1. Example of PATD-Test Question.

| Concept | PATD-Test Question |
|---------|--------------------|
| Plant tissue | Dita observed the cross-section of a plant's leaves. The results of the observations are as follows. |

Based on the results of observations made by Dita, it is known that the X network of cells is green, arranged quite tightly and is elongated perpendicular to the leaf surface. The correct conclusion regarding these observations is ...

- A. The cell structure allows the chloroplasts to be localized in the most strategic position to absorb maximum sunlight.
- B. The cell structure allows chloroplasts to have difficulty absorbing sunlight optimally.
- C. Elongated cell shape can help to store air properly.
- D. This part is able to reduce the transpiration rate in plants.
- E. The tight cell structure facilitates gas exchange in the leaves.

The reason you chose that answer is ....

- A. X network can be modified into stomata
- B. Photosynthetic events only occur in leaf organs
- C. X tissue development comes from epidermal tissue
- D. X network serves to transport water and mineral substances
- E. The X network is the result of differentiation from the parenchyma network

How do you feel about the answers you have chosen?

- A. Sure  
- B. Not sure

| Animal tissue | The bladder serves to store urine temporarily before it is removed from the body. The bladder has epithelial tissue that supports this function. How does the epithelial tissue in the bladder work? |

- A. The shape of the cells will flatten when the bladder fills with urine and will return to a cuboid when the bladder is empty.
- B. The shape of the cell is a cuboid when the bladder fills with urine and flattens when the bladder is empty.
- C. The cells in the apical layer are flat and multilayered and can become cylindrical when filled with urine.
- D. multilayered cylindrical cells that are elastic and can store urine.
- E. The cells in the apical layer are cuboid and in the basal layer are cylindrical to accommodate urine.

The reason you chose this answer is that the bladder has epithelium tissue ....

- A. transitional  
- B. stratified cuboidal  
- C. stratified columnar  
- D. stratified squamous  
- E. simple columnar

How do you feel about the answers you have chosen?

- A. Sure  
- B. Not sure
2.3 Instruments
Data were collected using the Logically and empirically validated Plant-Animal Tissue Diagnostic Test (PATD-Test) instrument. The PATD-Test consists of 30 questions.

2.4 Data Analysis
Logical validity data by expert validators were analyzed descriptively quantitatively, while empirical validity data which included validity, reliability, difficulty level, and different power were analyzed with the help of software. The validity uses the r-product moment table guidelines in providing interpretation, while the reliability test uses the Alpha Cronbach formula. Furthermore, the analysis of the results of the identification of misconceptions was carried out descriptively quantitatively based on the categories developed by Peşman & Eryılmaz (2010).

3. Results and Discussion

3.1 PATD-Test Instrument Quality
Logical validity is carried out by material and assessment expert validators and field practitioners. The validity result of the material is 100% which means that the material in the PATD-Test instrument is accurate and there are no misconceptions. Meanwhile, the results of the construct validity of the assessment experts were 94.00% and the practitioners were 99.66%. The mean of logical validity is 98.41% which is classified as very valid. After validating experts and field practitioners, then empirical validation is carried out, namely on students.

Empirical validation includes the validity, reliability, difficulty and discrimination index of the items. The results show that the 30 questions used are valid, with a reliability of 0.81 for tier 1 and 0.76 for tier 2, this shows that the questions have high reliability [19]. The difficulty index showed in Table 2 and index of discrimination power of the items test showed in Table 3.

| Concept            | Category  | Question number | Percentage of total item | Average of difficulty index |
|--------------------|-----------|----------------|--------------------------|------------------------------|
| Plant and animal   | Easy      | 5, 12, 18, 24, 27, and 29 | 20.00%                   | 0.73                         |
| tissue             | Medium    | 1, 2, 3, 4, 7, 8, 9, 10, 11, 14, 16, 18, 19, 20, 21, 22, 23, 26, and 30 | 63.33%                  | 0.56                         |
|                    | difficult | 6, 13, 15, 25, and 28 | 16.67%                   | 0.28                         |

| Concept            | Category | Question number | Average of discrimination index |
|--------------------|----------|----------------|--------------------------------|
| Plant and animal   | Moderate | 15, 23, 25, and 29 | 0.60                           |
| tissue             | Good     | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 16, 17, 18, 20, 21, 24, 26, and 27 |                              |
|                    | Very good| 11, 14, 19, 22, and 28 |                              |

Based on Table 1 it is known that as many as 6 questions were included in the easy category, 18 questions are in the medium category, and 5 questions are in the difficult category. According to Arikunto (2013), a good question is one with a low difficulty level of 25%, 50% moderate, and 25% difficulty of the total item. The average of discrimination index showed a result of 0.60. These results indicate that the test is good for use and is able to differentiate between students who have a good understanding of the concept from students whose understanding of the concept is poor or weak [20,21]
3.2 Results of the Identification of Student Misconceptions

The identification of misconceptions in 758 high school students on plant and animal tissue material by using the PATD-test showed a mean percentage of 25.55%. The results of the implementation of the PATD-Test for students on plant and animal tissue material showed an answer pattern between tier-1, tier-2, and tier-3. The answer patterns are categorized as shown in Figure 1.

Based on Figure 1, the average misconception in plant tissue material is 27.20%, while in animal tissue material is 23.90%. The items that contribute greatly to the average percentage of misconceptions are shown in question number 6, which is about the concept of aerenchyma in plants that live in aquatic habitats. Most of the students chose the answer that the ability of water lily plants to float on the surface of the water was related to the high chlorophyll content in these plants. This is considered wrong because the correct concept is related to the presence of aerenchyma networks that have large intercellular spaces to facilitate internal gas diffusion [22].

Misconceptions that occur in students are caused by several things, one of which is the difficulty factor in understanding the concept. Plant tissue material contains concepts that tend to be abstract so it is difficult to visualize directly and must use the help of tools such as microscopes or images to make it clear so as not to cause different perceptions [23,24].

Misconceptions also occur in the concept of water and mineral salt transportation. The correct concept is that the entry of water and mineral salts through root hairs is due to differences in concentration gradients [25]. The water will move towards the cortex cells before finally reaching the central cylinder. There are two kinds of extravascular transport mechanisms, namely simplast and apoplast. Simplast is the transportation of water and solutes from cell to cell through the living parts of a plant cell such as the cytoplasm. Groundwater displacement occurs by osmosis and active transport through plasmodesmata. Meanwhile, apoplasts transport water and solutes through cell walls and spaces between cells [26]. Previous research shows that students experience quite high misconceptions about the concept of water and mineral salt transportation by 76.7% [27,28].

The next discussion is a misconception that occurs in animal tissue material. The highest contribution to misconceptions was shown by item number 16 with the mean percentage of students who experienced misconceptions of 35.88%. Item number 16 regarding the concept of epithelial tissue. The mistake that often occurs is that students do not correctly determine the structure of the layered flat epithelial tissue based on the pictures provided regarding its function in protection in the oral cavity. Furthermore, a fairly large misconception contribution also occurred in the concept of
smooth muscle tissue in item 22, amounting to 34.43%. Misconceptions in students regarding smooth muscle tissue are related to the structure of smooth muscle tissue related to its function in the body. Students seem unfamiliar with terms that are often mentioned in textbooks. For example, spindle-shaped smooth muscle cells. Students assume that the spindle shape is the same as a cylindrical shape. Furthermore, item number 24 regarding compact bone tissue is 31.13%. Misconceptions in compact networks relate to the supply of nutrients received by compact bones. Many students answered that compact bones were able to produce their own nutrients, even though the supply of nutrients was still carried out by blood vessels in the Havers duct of bone tissue. Based on previous research, quite a lot of misconceptions occur in animal tissue, especially bone tissue[29].

Overall, misconceptions in plant tissue material and animal tissue are included in the low category <30%, however, this must be a concern and be addressed immediately so as not to continue in the next material concept [30]. Misconception in epithelial tissue is a picture that contains inaccurate captions in textbooks [5–7,31]. Incomplete teacher explanations can also lead to different perceptions of students. The teacher plays an important role to assist students in constructing their preconceptions with new knowledge to form a complete concept so that misconceptions do not occur and complete learning can be achieved [25]. Misconceptions are important things to overcome because they can prevent students from assimilating new knowledge. Misconception detection needs to be done early on so that teachers can evaluate the learning process including the teaching materials that have been used so far.

4. Conclusion
The results of the identification of students' misconceptions on the material of plant and animal tissue using the PATD-Test showed the percentage of 27.20% and 23.90%, respectively. Misconceptions can occur, one of which is the textbook used in the learning process. Further research can analyze the textbooks used and develop teaching materials that are free from misconceptions.

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