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Misconception Analysis of Cell Material Using Four-Tier Multiple Choice Diagnostic Test

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Abstract: *The purpose of students learning biology is to understand the concepts in biology, be able to connect one concept to another, and apply the learned concepts in daily life. Inability to properly connect concepts may cause misconceptions that will affect students' achievement. Therefore, the purpose of this study is to analyze students' misconceptions on the topic of cells using a four-tier multiple choice diagnostic test. The research method used is research and development. The subjects in this study were 36 students of class XI science at SMA Muhammadiyah 5 Rancaekek. The results of developing a diagnostic test using the content validity ratio (CVR) method produced a CVR value of 0.75 (CVR ≥ 0.672) and the content validity index (CVI) method produced a value of 0.87 so that the developed diagnostic test was feasible to use. The results of the analysis of misconceptions experienced by students showed that on the topic of chemical components making up cells 10.42%, cell structure 10.42%, cell function 13.89%, differences between animal and plant cells 17.36%, and bio-processes in cells 11.81%. Overall, the misconceptions experienced by students regarding cell material were 12.78% (misconceptions > 10%), which means that a misconception experienced by students was considered significant.*

Keywords: *misconception; four-tier multiple choice; cell material.*

1. INTRODUCTION

In the Indonesian education curriculum, biology is one of the branches of knowledge that is required for students from elementary to high school, with the aim of developing students' abilities to understand, connect, and apply biology concepts and solve problems in everyday life (Triwiyanto, 2022). In a study it was proven that sometimes the concepts possessed by students were not always in accordance with established scientific knowledge (Wright et al., 2022). Interrelated relationships between concepts in biology learning can have an impact on the formation of subsequent concepts. Thus, each concept taught can influence students' understanding of subsequent concepts (Malikha & Amir, 2018). However, students' initial concepts are often misconceptions, namely the concepts possessed by students conflict with the concepts raised by experts (Megawati, Ibrahim & Haryono, 2017).

Errors in students' understanding of learning concepts can be caused by several factors, including wrong generalizations based on experience, misinformation from teachers who are not careful, teacher misunderstandings, and misinformation in textbooks that can affect students' conceptual learning (Chazbeck & Ayoubi, 2018). If there are misconceptions, this can affect students' understanding of actual scientific concepts, which can make it difficult for students to understand the concepts conveyed by the teacher. As a result, the absorption of new knowledge by students will be hampered (Zhao et al., 2021). Students who experience misconceptions tend to defend concepts that they

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believe are true, so that these misconceptions can be stable and difficult to change. The causes of misconceptions can come from the students themselves, the community, teachers, the learning process, or the reading sources used by students (Taslidere, 2016).

Cell material helps students understand the dynamics of life processes starting from the cell level as the basic unit of life, to include the levels of organisms, communities and ecosystems (Saefi, Lukiati & Suarsini, 2017). A research study shows that students aged 16 to 19 have inadequate understanding of cell structure and concepts related to genetics, such as nucleic acids, alleles, chromosomes, and cell division (Kılıç, Taber & Winterbottom, 2016). Specifically regarding misconceptions in mastering basic concepts in cell material there are at least three levels, namely (1) misunderstandings and obstacles in managing scientific concepts acquired during learning, (2) characteristics of cell material having complexity and cellular structural properties that cannot be observed by the human eye directly, and (3) in modern cell materials growing rapidly this creates challenges for teaching (Suwono et al., 2019).

Teachers have an important role in helping students understand and learn the concepts taught in class. Tools for exploring misconceptions in general can be researched using concept maps, interviews, multiple choice questions, two-tier multiple choice diagnostic tests and four-tier multiple choice can also be used to identify student misconceptions (Sheftyawan, Prihandono & Lesmono, 2018). Interviews can explore misconceptions but are time-consuming and unsuitable for diagnosis on a large scale. Then, the test tool in the form of multiple choice questions cannot distinguish whether students get the correct answer because of the knowledge they have or it is just coincidence. Therefore, the two-tier multiple choice test developed by Treagust is divided into a choice of answer sections at the first tier and a reason section at the second tier. This test has the advantage of being able to detect and know the location of misconceptions in students but has several weaknesses, namely not being able to identify whether the wrong choice of students is due to a lack of knowledge or because of misconceptions (Sreenivasulu & Subramaniam, 2014).

To increase accuracy in detecting misconceptions, a belief index is needed which refers to individual judgments (Salame, Krauss & Suleman, 2022). Therefore, a diagnostic test tool was developed which was formed by adding a confidence index segment to multiple choice questions. Even though the multiple choice questions added to the confidence index are an improvement over the usual multiple choice questions, the essential deficiencies still exist (Kaltakcigurel, Eryilmaz & Mcdermott, 2017). Attempts have been made to add confidence to the third tier of the two-tier multiple choice test and extend it to a three-tier multiple choice test where students only make one confidence index assessment of the answer section. It cannot be known if students have different confidence indices in the answer section and the reason section. Therefore, a four-tier multiple choice test is formed by adding a confidence index segment to the answer section and the reason section. These diagnostic tests, have become better and more effective tools for diagnosing misconceptions. Currently, there are several examples of applying the four-tier multiple choice test to explore misconceptions in the world (Sreenivasulu & Subramaniam, 2014). According to Zhao et al., (2021) the use of a four-tier multiple choice test is an effective test instrument for identifying students' misconceptions about blood circulation. This is supported by Yang & Lin (2015) that four-tier multiple choice can identify misconceptions both in the level of answers and reasons and provide information about the level of trust. According to Fariyani, Rusilowati & Sugianto (2015) the advantages of a four-tier multiple choice diagnostic test can reveal students' understanding of concepts, diagnose in-depth misconceptions, and determine material that requires further emphasis.

Based on these problems, this study aims to analyze misconceptions using four-tier multiple choice on cell material. The selection of cell material was due to topics such as the structural differences between animal and plant cells and their functions related to tissue function and passive and active transport mechanisms. Cell material also has complexity, one of which is the

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chemical processes that occur in cells and cells are microscopic in nature.

2. RESEARCH METHOD

The sample of this research is SMA Muhammadiyah 5 Rancaekek, Bandung Regency. The sampling method used a purposive sampling technique and the number of samples was 36 students of class XI for the 2022/2023 academic year. Sampling method for certain considerations.

In this study, the research and development method was used (Sugiyono, 2017). The development carried out is product development oriented, namely in the form of a four-tier multiple choice diagnostic test. The procedure for developing a four-tier multiple choice diagnostic test consists of five stages, namely: 1) preliminary investigation, 2) the design phase 3) the construction/realization 4) the stage of evaluation and revision, and 5) the stage of implementation.

The validity test of this diagnostic test was carried out by six experts based on the material, construction, and language aspects. The validity test was also carried out using the content validity ratio (CVR) method. The calculation of the CVR value is based on Lawshe's equation as follows:

$$\text{CVR} = \frac{n_e - \frac{\text{N}}{2}}{\frac{\text{N}}{2}}$$

Information:
n_e : the number of validators who declared valid.
N : total number of validators

The CVR calculation results for each assessment criterion are then compared with the minimum CVR value to determine whether or not the assessment criteria are valid. The minimum CVR value criterion for the number of validators of six people with a significance level of .05 is greater than or equal to 0.672 (CVR ≥ 0.672) (Wilson, Pan, & Schumsky, 2013). In addition, the overall test validity was determined using the content validity index (CVI) method. The CVI value is the average of the CVR values. The CVI score criteria are as follows:

Table 1. Criteria for CVI Calculation Results

Range	Category
CVI ≥ 0,68	Perfect fit
0,34 ≤ CVI ≤ 0,67	Appropriate
CVI < 0,34	It is not in accordance with

The four-tier multiple choice diagnostic test questions used totaled 20 items consisting of five topics on cell material, namely the topic of chemical components that make up cells, cell structure, cell function, differences in animal cells & plant cells, and bio-processes in cells. The four-tier multiple choice diagnostic test that has been developed will produce several patterns of student answers that show the profile of students' conceptions, as shown in the table below. Each of the students will be determined based on the pattern of answers they give for each level.

Table 2. Decisions on Student Answer Patterns

Tier One	Tier Two	Tier Three	Tier Four	Decision
True	Sure	True	Sure	SC
True	Sure	True	Not sure	LK
True	Not sure	True	Sure	LK
True	Not sure	True	Not sure	LK
True	Sure	False	Sure	FP
True	Sure	False	Not sure	LK
True	Not sure	False	Sure	LK
True	Not sure	False	Not sure	LK
False	Sure	True	Sure	FN
False	Sure	True	Not sure	LK
False	Not sure	True	Sure	LK
False	Not sure	True	Not sure	LK
False	Sure	False	Sure	MSC
False	Sure	False	Not sure	LK
False	Not sure	False	Sure	LK
False	Not sure	False	Not sure	LK

(Gurel, Eryilmaz, & McDermott, 2017)

Information:
SC: Scientific Conception; LK: Lack of Knowledge; FN: False Negatif; FP: False Positif; MSC: Misconception

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According to Gurel, Eryilmaz & McDermott (2015) there are various levels of understanding that describe the state of students' conceptions regarding a science material known as the conception profile. These conception profiles include:

a. Scientific conception is an understanding that is in accordance with the actual conception of science.
b. Lack of knowledge is a type of students' understanding that is incomplete and unsure because they have little information in drawing the correct conclusions about a concept.
c. False positive is a type of student conception that is wrong in doing a reasoning for the correct answer they choose.
d. False negative is a type of student understanding that is correct in reasoning but wrong in choosing the correct answer.
e. Misconception is a type of student understanding in which inaccurate understanding of concepts, wrong use of concepts, wrong classification of examples of applying concepts, different meanings of concepts, and incorrect hierarchical relationships of concepts.

To determine the percentage of MSC/SC/LK/FP/FN per topic in cell material, the following formula is used:

$$M = \frac{f_M}{N} \times 100\%$$

Information:
M : percentage of MSC/SC/LK/FP/FN on the topic of cell material
f_M : number of MSC/SC/LK/FP/FN students
N : number of questions

Furthermore, the calculation of all students' misconceptions is carried out using the following formula:

$$P = \frac{S}{N} \times 100\%$$

Information:
P : percentage of students' conception level
S : number of students identified as MSC/SC/LK/FP/FN
N : the number of students who took the test

A misconception is considered significant if the misconceptions experienced by students are 10% or more of the total (Caleon & Subramaniam, 2010).

3. RESULTS AND DISCUSSION (11 pt, bold)

The process of developing a four-tier multiple choice diagnostic test is descriptive in nature. The development of this instrument refers to research conducted by Cheong et al. (2015); Wola et al. (2020); Zhao et al. (2021). The development stages carried out consist of five stages which will be described, as follows:

1) Preliminary Investigation

The development of the diagnostic test instrument begins with an analysis of core competencies and basic competencies in senior high school contained in the 2013 curriculum. This analysis is carried out because it is a reference for achieving minimum graduate competencies at the senior high school educator level. The analysis also aims to determine indicators. This indicator has a function as a guide in the problem so that it can fulfill content validity. This means that the questions compiled can represent proportionally and representatively from all descriptions of the subject matter which are predicted to often cause misconceptions in students.

After the indicators are determined, then create questions or questions in the form of an open ended two-tier multiple choice. Each question consists of a core question and an open reason. Each of the core questions consists of four answer choices. An open reason is a blank that will be filled in by the student with reasons why the student chose that answer. The results of the reasons given by students are then adjusted with indicators, clarity regarding language, and answer distractors.

2) The Design Phase

The next diagnostic test instrument development process is the design stage which describes the transformation from an open-ended two-tier multiple choice diagnostic test to a four-tier multiple choice diagnostic test. According to Gurel, Eryilmaz, & McDermott (2017) transformation of a diagnostic test is a step taken to change the form of a test that is developed in a

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structured manner so that a diagnostic test is obtained that is in accordance with the research objectives. The transformation of a two-tier open-ended test into a four-tier multiple choice test is based on the format or design of the two diagnostic tests. The transformation process that is carried out next is to place the three best reasons with the highest frequency indicating misconceptions in the choice of reasons or the third tier of the developed four-tier multiple choice diagnostic test.

The complete four-tier multiple choice diagnostic test consists of answer choices in the first tier, confidence level in the second tier, reason choices in the third tier, and confidence level in choosing the reasons in the fourth tier. The level of confidence used in this instrument is focused on sure and unsure choices. This is so that a specification of answers is obtained which directly directs students so that it is easier in the process of identifying misconceptions.

(**Tier 1**) The cell is the basic structure and the smallest functional unit of living things. Inside a cell, there is deoxyribonucleic acid which functions as ….
A. Composer of cell membranes, helps transport certain substances, and accelerates chemical reactions in cells
B. Forming cell structures and producing energy
C. The main components of the plasma membrane
D. Regulatory inheritance and control cell activity
E. Solvent of organic and inorganic materials

(**Tier 2**) Are you sure your answer is correct?
A. Sure
B. Not sure

(**Tier 3**) The reason is because ….
A. Deoxyribonucleic acid can be found in the nucleus of cells
B. Deoxyribonucleic acid can be found in the plasma membrane
C. Deoxyribonucleic acid can be found in the cytoplasm
D. Other reasons: ……

(**Tier 4**) Are you sure your reasons are correct?
A. Sure
B. Not sure

Figure 1. Examples of four-tier multiple choice questions used in research

3) The Realiziation/Construction

The construction process of the four-tier multiple choice diagnostic test instrument is adjusted to the design described in the previous stage. This construction is a form of realization of a four-tier multiple choice diagnostic test instrument which is intended to be used to level students' understanding and identify misconceptions in cell material. At this stage the placement of the correct answer, the correct reason, the answer distractor and the reason distractor are placed randomly on each question. The goal is that there is no consistent pattern regarding the correct answers and reasons so as to prevent students from guessing the answers and reasons. Apart from that, the instructions for working on the questions and the time for working on the questions must also be clear because unclear instructions for working on the questions can result in unsatisfactory results (Yang & Lin, 2015). What's more, students are not too used to it or have just discovered a test in the form of a four-tier multiple choice. A good test must also provide sufficient time for students to think about deciding the most correct answer from the choices given (Gurcay & Gulbas, 2015).

4) The Stage of Evaluation and Revision

At this stage a quality test is carried out from the development of a four-tier multiple choice diagnostic test. An assessment tool is said to have good quality if the measuring tool meets the test requirements (Korur, 2015). The validity test carried out is content validity and construct validity.

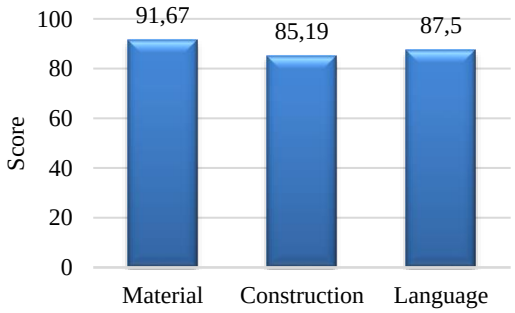

Figure 2. Results of a four-tier multiple choice diagnostic test conducted by experts

Based on Figure 2. the material aspect obtained a score of 91.67 with a very good interpretation according to Riduwan (2013), thus indicating that

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the content of the material that has been developed is in accordance with the core competencies and basic competencies of class XI cell material in the 2013 curriculum. This is in accordance with the opinion of Arikunto (2013) that the validity of the material aspect is validity in terms of content whether the contents represent representatively of the entire material. Furthermore, on the construction aspect, a score of 85.19 was obtained with a very good interpretation according to Riduwan (2013). Tests that meet construction validity have questions that can measure every aspect in the competency achievement indicators (Surapranata, 2004). In the aspect of language, a score of 87.5 was obtained with a very good interpretation according to Riduwan (2013), so that overall the four-tier multiple choice diagnostic test fulfilled these three aspects, namely: material, construction, and language, so that overall the diagnostic test four-tier multiple choice that already fulfills these three aspects.

Based on the results of the analysis using the content validity ratio (CVR) method it was declared valid because the value was 0.75 (CVR ≥ 0.672) while using the content validity index (CVI) method it was stated in a very appropriate category because the value was 0.87 (CVI ≥ 0.68), so that based on the data analysis performed it can be concluded that the developed four-tier multiple choice diagnostic test can be used to measure students' conception profiles. At the time of developing a diagnostic test, discussion with experts is needed in order to produce a good diagnostic test. According to Kurniawati (2021) an understanding and ability to master material is also needed in preparing instruments to produce good instrument items.

5) The Stage of Implementation

At this stage, the developed four-tier multiple choice diagnostic test instrument was then implemented for students to uncover misconceptions experienced by students on cell material. The profile of students' conceptions was obtained from the pattern of answers given by students. Decisions on student answer patterns are divided into five, namely conceptual understanding or scientific conception (SC), misconception (MSC), false positives (FP), false negatives (FN), and lack of knowledge (LK) (Gurel, Eryilmaz, & McDermott, 2015). This category is seen based on the answers and level of confidence (confidence rating) given by students in the first tier to the fourth tier.

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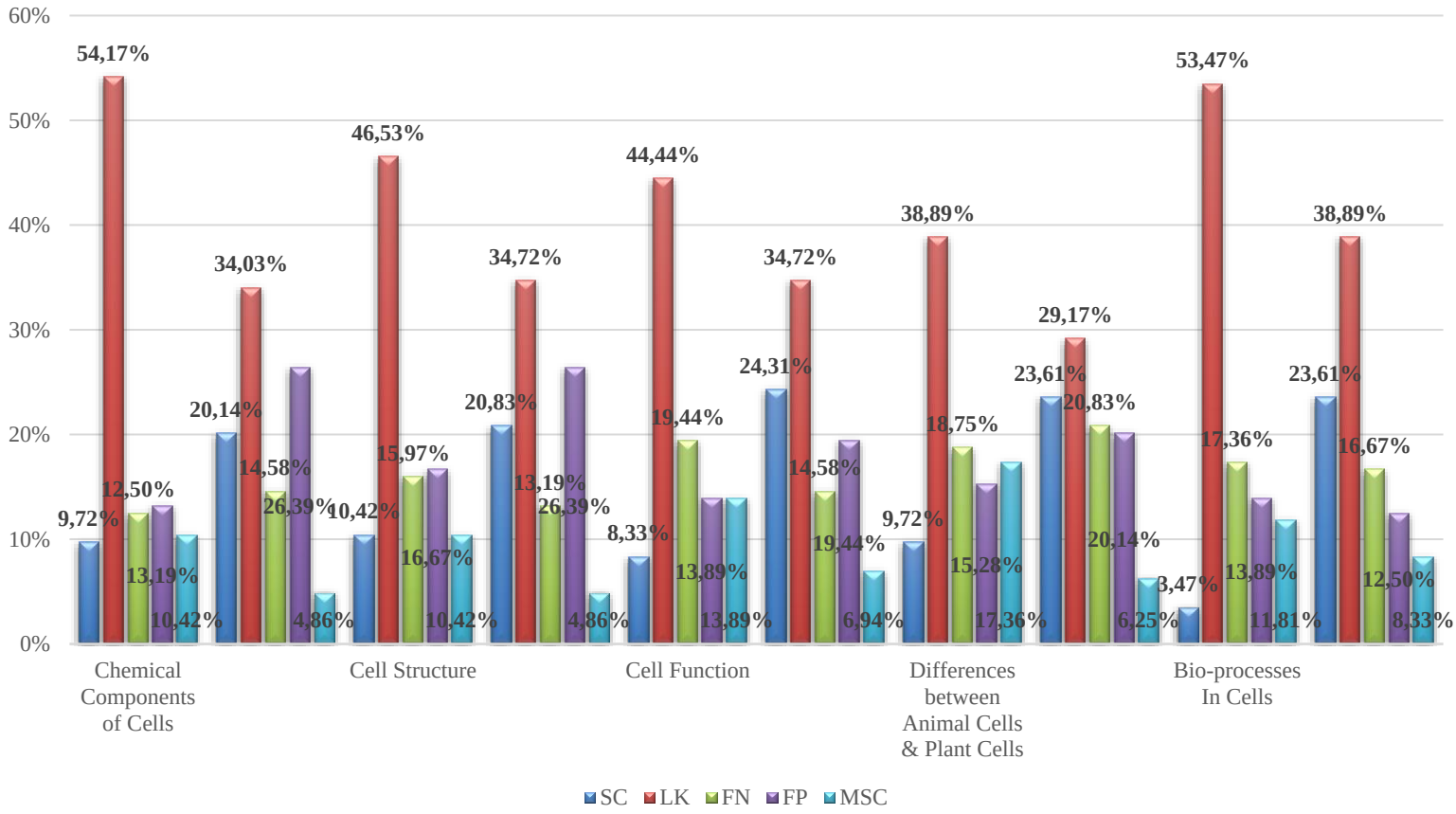

Figure 3. The results of the percentage of decisions on student answer patterns based on topics in cell material

Based on Figure 3. the results show that all topics in the cell material have percentages above 10% which indicates that each student topic has significant misconceptions. On the topic of differences between animal cells and plant cells, the percentage of misconceptions was the highest at 17.36%. The questions posed regarding this topic were organelles, structure, and function of organelles that differentiated them from animal and plant cells, but students had an erroneous understanding regarding the concepts of the topic, while on the topic of cell function students also still had many erroneous concepts. such as the name of the energy-producing organelle, to the role of the peroxisome organelle for our body". Next regarding "what organelles are involved in the endomembrane system? And the function of the endomembrane system?" which includes the nuclear membrane, endoplasmic reticulum, golgi bodies, lysosomes, and the plasma membrane. The function of the endomembrane system is to regulate the transportation of materials and information in eukaryotic cells. The organelles involved in the endomembrane system work together to process proteins and lipids, regulate the transportation of materials from one organelle to another, and ensure that the required materials are stored in the right places. In addition, the endomembrane system is also involved in the formation and breakdown of intracellular materials, as well as in detoxification.

The next topic is, bio-process in cells has a percentage of 11.81%. The topic is related to cell division and cell membrane transport (diffusion and omosis). Related to this topic, direct experience is needed so that students can better understand and observe the process. This is in accordance with research conducted by Awal, Afidah, & Wahyuni (2018) that misconceptions occur in cell material because cells are abstract in

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nature, many foreign terms, and the language is difficult to understand.

Students in this study experienced misconceptions about cell material due to the cell concept which is a very abstract concept and difficult to understand because it cannot be seen directly with the naked eye. In addition, concepts within the cell such as cell organelles, the role of each organelle, and the processes that occur within the cell can also be difficult to understand. Furthermore, some cell concepts may conflict with students' initial perceptions, so they tend to ignore or set aside these conflicting concepts. Lack of practicum or demonstrations can also lead to misconceptions in students, and finally, learning resources used by students such as textbooks or learning videos may not present cell concepts in an easy-to-understand way, or are too simple so that important details are overlooked.

Therefore, it is important for teachers/instructors to pay attention to misconceptions that occur in students and find ways to help students understand the cell concept better by providing material that is easier to understand, conducting demonstrations and practicums, and emphasizing the importance of understanding the cell concept.

In Figure 3. each topic in cell material has a high percentage of lack of knowledge (LK). According to Adrianto, Candramila, & Ariyati (2017) lack of knowledge can be triggered by internal and external factors. Internal factors are caused by students not being able to develop an understanding of concepts that have a higher level of difficulty. This is because the inability of students to connect basic concepts with higher concepts is caused by cognitive biases. According to Andry, et al. (2019) that the lack of knowledge possessed by students can cause misconceptions. The lack of knowledge that occurs in students can be overcome by providing additional information related to concepts that students have not yet understood.

In Figure 3 scientific conception (SC) or correct understanding of the concept is classified as low because only the topic of cell structure is above 10% while other topics are still below 10%. False negative (FN) is a type of student understanding that is correct in reasoning but wrong in choosing answers in the first ¬ tier. Based on the figure, the highest percentage of false negatives is found on the topic of cell functions with a percentage of 19.44%. False negatives occur when students are wrong in choosing answers at tier 1 but on the tier 2 and tier 4 confidence index many students answer confidently, but the reasons students choose at tier 3 are correct. This can be interpreted that in this condition there is little information (less information) owned by students, in this situation it is considered not problematic because it is caused by the carelessness of students in giving answers (Istiyani, Muchyidin, & Raharjo, 2018). The highest false positives (FP) were found on the topic of cell structure with a percentage of 16.87%. The condition of students experiencing false positives where students answer correctly at tier 1 and wrong at tier 3 and have confidence in tier 2 and 4. False positives can occur because students lack understanding (deficiency understanding) with a concept (Yusuf, Jusniar, & Yunus, 2022).

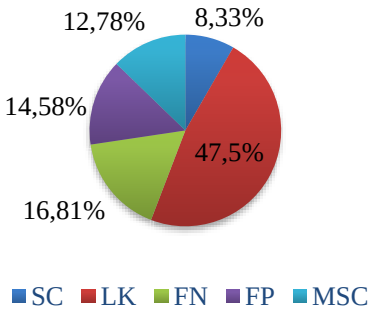

Figure 4. The results of the percentage of the overall decision on the pattern of student answers

Based on Figure 4 it shows that overall the misconceptions experienced by students are considered significant because they produce a percentage of 12.78%, while scientific conception (SC) or correct understanding of concepts produces 8.33%, which means that students' understanding of the concept of cell material is still relatively low. Lack of knowledge (LK) or at least information owned by students dominates because it produces a percentage of 47.5%. False positives (FP) generate 14.58%, while false negatives (FN) generate 16.81%. Based on this, the developed diagnostic test can be used to describe the state of the student's profile on cell

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material. A four-tier multiple choice diagnostic test can also be used to detect misconceptions about genetic material (Wulandari, Gusmalini, & Zulfarina, 2021).

According to Machová & Ehler's (2021) research that students still experience many misconceptions about cell material and genetics. The main reasons why there are difficulties in learning the material are the nature of the topic, the teaching style of the teacher, the study and study habits of the students, the students' negative feelings and attitudes towards the topic and the lack of resources. To overcome these difficulties and make biology learning more effective, it is recommended to teach biology through the use of visual materials, teach through practical work, reduce the content of the biology curriculum, use various learning techniques, teach biology by connecting topics with everyday life, and make biology learning be interesting (Çimer, 2012). One of them is by using the guidance of a technology and instruction that can help students to integrate new concepts into their previous understanding (Cisterna, Williams, & Merritt, 2013).

Research conducted by Park & Liu (2021) found that student misconceptions are closely related to learning science and affect student academic achievement in science subjects. According to research conducted by Assimi et al. (2022) shows that students and prospective teachers have misconceptions about cell material. In most cases, the teacher is the source of students' misconceptions. Teachers need to be aware of misconceptions in biology lessons in class and how to overcome them, as researchers and educators have suggested and examined effective practices to prevent and correct misconceptions (Kumandaş, Ateskan, & Lane, 2009). According to Atchia, Chummun, & Luckho (2022) teachers or educators can choose appropriate and structured learning methods in order to be able to identify and eliminate student misconceptions based on the type and origin of misconceptions.

4. CONCLUSION

The conclusion of this study is that the four-tier multiple choice diagnostic test that was developed is feasible to be used in describing the state of students' conception level in cell material. The results showed that the misconceptions experienced by students were 12.78% (misconceptions> 10%) meaning that the misconceptions experienced by students in cell material were considered significant, while scientific conceptions or correct understanding of concepts produced 8.33%, which meant students' understanding of the concepts of cell material is still relatively low.

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6. REFERENCES

Adrianto, O. M., Candramila, W., & Ariyati, E. (2017). Analisis Konsepsi dan Miskonsepsi Siswa Kelas XII IPA. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa (JPPK), 6*(4), 1-9.

Andry, S., Putra, U., Hamidah, I., & Nahadi. (2019). Pengembangan Tes Diagnostik Four-Tier Untuk Mengidentifikasi Miskonsepsi Peserta Didik Materi Gelombang dan Optik. *Jurnal Pendidikan Fisika, 8*(1), 1-9.

Arikunto, S. (2013). *Dasar-dasar Evaluasi Pendidikan Edisi 2*. Jakarta: Bumi Aksara.

Assimi, E., Idrissi, R. J., Zerhane, R., & Boubih, S. (2022). The use of a three-tier diagnostic test to investigate conceptions related to cell biology concepts among pre-service teachers of life and earth sciences. *Journal of Biological Education, 56*(10), 1-28.

Atchia, S. M., Chummun, D., & Luckho, S. (2022). Use of design thinking as a strategy to identify and clear students' misconceptions in photosynthesis: a case study. *journal of Biological Education, 56*(7), 1-18.

Awal, R., Afidah, M., & Wahyuni, S. (2018). Analisis Miskonsepsi Biologi Sel Pada Mahasiswa Prodi Pendidikan Biologi Universitas Lancang Kuning. *Lectura Jurnal Pendidikan, 9*(1), 86-94.

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Caleon, I. S., & Subramaniam, R. (2010). Do students know what they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions. *Research in Science Education, 40*(3), 313-337.

Chazbeck, B., & Ayoubi, Z. (2018). Resources used by Lebanese secondary physics teachers' for teaching electricity: Types, objectives and factors affecting their selection. *Journal of Education in Science, Environment and Health (JESEH), 4*(2), 118-128.

Cheong, I. P.-A., Johari, M., Said, H., & Treagust, D. F. (2015). What Do You Know about Alternative Energy? Development and Use of a Diagnostic Instrument for Upper Secondary School Science. *International Journal of Science Education, 37*(2), 210-236.

Çimer, A. (2012). What Makes Biology Learning Difficult and Effective: Students' Views. *Educational Research and Reviews, 7*(3), 61-71.

Cisterna, D., Williams, M., & Merritt, J. (2013). Students' Understanding of Cells & Heredity: Patterns of Understanding in the Context of a Curriculum Implementation in Fifth & Seventh Grades. *The American Biology Teacher, 75*(3), 178-184.

Fariyani, Q., Rusilowati, A., & Sugiyanto. (2015). Pengembangan four-tier diagnostic test untuk mengungkap miskonsepsi Fisika siswa SMA kelas X. *Journal of Innovative Science Education, 4*(2):41-49.

Gurcay, D., & Gulbas, E. (2015). Development of Three-Tier Heat, Temperature and Internal Energy Diagnostic Test. *Research in Science and Technological Education, 33*(2), 197-217.

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A Review and Comparison of Diagnostic Instruments to Identify Students' Misconceptions in Science. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(5), 989-1008.

Gurel, K. D., Eryilmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *ReseaRch in science & Technological educaTion, 35*(2), 238-260.

Istiyani, R., Muchyidin, A., & Raharjo, H. (2018). Analysis of Student Misconception on Geometry Concepts Using Three-Tier Diagnostic Test. *Jurnal Cakrawala Pendidikan, 37*(2), 223-236.

Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, C. L. (2017). Development and Application of a Four-tier Test to Assess Pre-service Physics Teachers' Misconceptions about Geometrical Optics. *Research in Science & Technological Education, 35*(2), 1-23.

Kılıç, D., Taber, K. S., & Winterbottom, M. (2016). A Cross-national Study of Students' Understanding of Genetics Concepts: Implications from Similarities and Differences in England and Turkey. *Education Research International.*

Korur, F. (2015). Exploring Seventh-Grade Students' and Pre-service Science Teachers' Misconceptions in Astronomical Concepts. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(5), 1041-1060.

Kumandaş, B., Ateskan, A., & Lane, J. (2009). Misconceptions in biology: a meta-synthesis study of research, 2000–2014. *Journal of Biological Education, 53*(4), 350-364.

Kurniawati, K. (2021). Analisis validitas isi instrumen tes berpikir kritis IPS kelas V SD Kota Yogyakarta. *Pelita : Jurnal Penelitian Dan Karya Ilmiah, 21*(1), 130 - 140.

Machová, M., & Ehler, E. (2021). Secondary school students' misconceptions in genetics: origins and solutions. *Journal of Biological Education*(6), 1-14.

Malikha, Z., & Amir, M. F. (2018). Analisis miskonsepsi siswa kelas vb min buduran sidoarjo pada materi pecahan ditinjau dari kemampuan matematika. *Pi: Mathematics Education Journal, 1*(2), 75-81.

Megawati, Ibrahim, M., & Haryono, T. (2017). Pengembangan Perangkat Pembelajaran IPA Dengan Strategi Predict-Discus-Explain-Observe-Discus-Explain (Pdeode) untuk Meminimalisasi Miskonsepsi Siswa SMP. *JPPS (Jurnal Penelitian Pendidikan Sains), 7*(1), 1422-1430.

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DOI: 10.25134/quagga.v15i2.32

Park, M., & Liu, X. (2021). An Investigation of Item Difficulties in Energy Aspects Across Biology, Chemistry, Environmental Science, and Physics. *Research in Science Education, 51*(1), 43-60.

Riduwan. (2013). *Skala Pengukuran Variabel-variabel Penelitian*. Bandung: Alfabeta.

Saefi, M., Lukiati, B., & Suarsini, E. (2017). Developing Android-Based Mobile Learning On Cell Structure And Functions Lesson Subject Topic To Optimize Grade XI Students' Cognitive Comprehension. *Jurnal Pendidikan Sains*, *5*(2), 57-63.

Salame, I. I., Krauss, D., & Suleman, S. (2022). Examining learning difficulties and alternative conceptions students face in learning about hybridization in organic chemistry. *International Journal of Chemistry Education Research*, 83-91.

Sheftyawan, W. B., Prihandono, T., & Lesmono, A. D. (2018). Identifikasi miskonsepsi siswa menggunakan four-tier diagnostic test pada materi optik geometri. *Jurnal Pembelajaran Fisika*, *7*(2), 147-153.

Sreenivasulu, B., & Subramaniam, R. (2014). "Exploring Undergraduates' Understanding of Transition Metals Chemistry with the Use of Cognitive and Confidence Measures. *Research in Science Education, 44*(6), 1-28.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.

Surapranata. (2004). *Analisis, Validitas, Reliabilitas dan Interpretasi Hasil Tes*. Bandung: Rosda.

Suwono, H., Fachrunnisa, R., Lestari, U., & Lukiati, B. (2019). Cell Biology Diagnostic Test (CBD-Test) portrays pre-service teacher misconceptions about biology cell. *Journal of Biological Education, 55*(1), 82-105.

Taslidere, E. (2016). Development and use of a three-tier diagnostic test to assess high school students' misconceptions about the photoelectric effect. *Research in Science & Technological Education, 34*(2), 164-186.

Triwiyanto, T. (2022). *Manajemen kurikulum dan pembelajaran*. Jakarta: Bumi Aksara.

Wilson, F. R., Pan, W., & Schumsky, D. A. (2013). Recalculation of the Critical Values for Lawshe's Content Validity Ratio. *Measurement and Evaluation in Counseling and Development, 45*(3), 197-210.

Wola, R. B., Ibrahim, M., & Purnomo, T. (2020). Development of a Four-Tier Multiple-Choice Test on The Concept of Transport Across Membranes. *SEJ (Science Education Journal), 9*(2), 77-97.

Wright, L. K., Cortez, P., Franzen, M. A., & Newman, D. L. (2022). Teaching meiosis with the DNA triangle framework: A classroom activity that changes how students think about chromosomes. *Biochemistry and Molecular Biology Education*, *50*(1), 44-54.

Wulandari, S., Gusmalini, A., & Zulfarina, Z. (2021). Analisis miskonsepsi mahasiswa pada konsep genetika menggunakan instrumen four tier diagnostic test. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education), 9*(4), 642-654.

Yang, D. C., & Lin, Y. C. (2015). Assessing 10- to 11-Year-Old Children's Performance and Misconceptions in Number Sense Using a Four-Tier Diagnostic Test. *Educational Research, 57*(4), 368-388.

Yusuf, N., Jusniar, & Yunus, M. (2022). Analisis Miskonsepsi Siswa Kelas X.1 dan X.7 SMA Negeri 11 Makassar pada Konsep Larutan Elektrolit dan Reaksi Reduksi- Oksidasi dengan Menggunakan Three Tier Test. *ChemEdu (Jurnal Ilmiah Pendidikan Kimia)*, 3(2), 99–108.

Zhao, C., Zhang, S., Cui, H., Hu, W., & Dai, G. (2021). Middle School Students' Alternative Conceptions about the Human Blood Circulatory System Using Four-tier Multiple-choice Test. *Journal of Biological Education, 17*(3), 1-17.