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Misconception Analysis of Regulatory System Materials Using Four-Tier Diagnostic Test Instruments

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Article Info	Abstract
	The results of the 2018 PISA survey showed a decrease in the quality ranking of Indonesian education, so it is necessary to evaluate the difficulties of students in learning. One of the difficulties encountered is that students are unable to understand concepts precisely or misconceptions as agreed by scientists. Student misconceptions need to be identified because it will have a bad impact on students, one of which is low learning outcomes. This study aims to analyze the profile of grade XI students' misconceptions on regulatory system material with a four-tier diagnostic test instrument. The samples of this study were students of Class XI MIPA 1, XI MIPA 2, XI MIPA 3, and XI MIPA 4 SMA Negeri 2 Semarang with a total of 143 students. This type of research is descriptive research with non-experimental quantitative methods. The four-tier diagnostic test instrument in this study consisted of 20 items. Each question has four levels of answers; At the first level, there are four choices of answers and one choice of open answers, the second level is the level of confidence, at the third level there are four choices of reasons and one choice of open reasons, and the fourth level is the level of confidence. The conclusion of the misconception analysis of SMA Negeri 2 Semarang students showed that the misconceptions were in the low category. In general, the causes of student misconceptions are student assumption, lack of literacy, and lack of time to study.

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INTRODUCTION

In learning, difficulties are often encountered, both by teachers and students. Septiana (2014) and Suwarto (2013) stated that students are often unable to achieve their learning goals because they experience learning difficulties, especially students' lack of understanding of concepts. In the context of biology, difficulties come from foreign terms as well as the complexity of a concept due to the complexity of the information that forms a concept (NTSA, 2013). Students are still in the understanding stage so that it is possible to misinterpret concepts or misconceptions (Sa'adah, 2017).

The existence of foreign terms in biology, as well as these complex and interrelated concepts, make students often have difficulty understanding concepts which in turn experience misconceptions. In addition, what causes misconceptions that come from students themselves are students' preconceptions or initial concepts (Sholihat, et al, 2017; Islami et al, 2018), and students' ability to understand, including mistaking explanations from others (Abbas, 2019). Limited learning resources can also be a factor of misconception that causes misconceptions (Hala, et al., 2018). Misconceptions have a negative impact on students. Misconceptions that are not considered by the teacher will result in more material that is not completely understood so that it has an impact on low student learning outcomes (Yunita, 2015). Misconceptions that occur in students will be very difficult to eliminate if they are not addressed immediately. Each student will carry wrong concepts to the next level of education. The absence of identification of misconceptions from the start in students will create a barrier to restructuring knowledge, causing students to find it difficult to understand a concept (Vrabec & Proksa, 2016).

Diagnostic test is an evaluation tool that can be used to identify misconceptions (Khariroh, 2017). According to Gurel (2015), there are several methods commonly used to identify misconceptions, namely interviews, open-ended tests, multiple-choice tests, and multiple-tier tests. There are several developments in multiple-tier diagnostic tests, namely two-tier, three-tier, and four-tier (Amalia, 2018). The four-tier diagnostic test is the most accurate test because it measures not only students' ability to choose the correct response, but also the reasons behind their choice (Caleon, 2010). The use of a four-tier diagnostic test combined with a Confidence Rating (CRI) on the reason for the answer can identify misconceptions more accurately (Aprilyani, 2016 and Ismail, 2015). The four-tier diagnostic test can show how students think in answering the questions given even though their answers are not correct (Fariyani, 2017).

Four-tier diagnostic test, which is the development of the three-tier diagnostic test, consist of four levels of answers for each question. The first level is multiple choice questions with four distractors, one of which is an open answer and one answer key. The second level is the level of student confidence in choosing multiple choice answers with the CRI scale. The third level is the student's choice of reasons in answering questions with four distractors, one of which is an open answer, and one answer key. The fourth level is the level of student confidence in choosing multiple choice answers with the CRI scale (Caleon, 2010). One of the advantages of a multiple-choice test accompanied by open answer choices is that it is able to explore the strength of students' understanding with a level of answer confidence (Rukmana, 2019).

Research related to misconceptions and their identification using a four-tier diagnostic test instrument has been carried out by many researchers. Fariyani (2017) and Nurhany (2018) have conducted research related to the identification of misconceptions using a four-tier diagnostic test instrument, the results show that these instruments can reveal student misconceptions. Gurel (2015) conducted a study on the comparison of several diagnostic tests to identify misconceptions, the result was that the four-tier diagnostic test instrument was more accurate for identifying misconceptions than other diagnostic tests. Fratiwi (2017) also examined the comparison of two-tier diagnostic test instruments to four-tier diagnostic tests, the results were that the four-tier diagnostic test was more

accurate to identify misconceptions than the two-tier diagnostic test.

The formulation of the problem in this research is what is the profile of the misconceptions of Grade XI students on the material of the regulatory system with the four-tier diagnostic test instrument at SMA Negeri 2 Semarang.

The purpose of this study was to analyze the misconception profile of Grade XI students on the material of the regulatory system using a four-tier diagnostic test instrument at SMA Negeri 2 Semarang.

RESEARCH METHOD

This research is a descriptive research with non-experimental quantitative methods. The research data will be obtained using a test instrument, namely the four-tier diagnostic test instrument. The research data will be obtained with test and non-test instruments. The test instrument will be given after the learning of the regulatory system material is complete. Before the research, the four-tier diagnostic test instrument was tested first on students who were not included in the sample in order to determine the validity, reliability, difficulty level, and distinguishing power of each item.

The research was conducted at SMA Negeri 2 Semarang with a population of all students who had received the regulatory system material, namely 10 Class XII MIPA and 10 Class XI MIPA. The samples used were students of Class XI MIPA 1, XI MIPA 2, MIPA 3, and XI MIPA 4 with a total of 143 students. Data were collected through test. Analysis of the student's misconception profile can be seen from the combination pattern of student answers given. The combination of answers by Maharani (2019) is as shown in Table.

Table 1 Combinations of Four-Tier Diagnostic Test Answers

Category	Combination of Answers			
	Tier 1	Tier 2	Tier 3	Tier 4
Misconseption (Mi)	True	CRI > 1,5	False	CRI > 1,5
	True	CRI < 1,5	False	CRI > 1,5
	False	CRI > 1,5	False	CRI > 1,5
	False	CRI < 1,5	False	CRI > 1,5
Concept Disunderstanding (TP)	True	CRI > 1,5	True	CRI < 1,5
	True	CRI > 1,5	False	CRI < 1,5
	True	CRI < 1,5	True	CRI > 1,5
	True	CRI < 1,5	True	CRI < 1,5
	True	CRI < 1,5	False	CRI < 1,5
	False	CRI > 1,5	True	CRI < 1,5
	False	CRI > 1,5	False	CRI < 1,5
	False	CRI < 1,5	True	CRI < 1,5
	False	CRI < 1,5	False	CRI < 1,5
Error (E)	False	CRI > 1,5	True	CRI > 1,5
	False	CRI < 1,5	True	CRI > 1,5
Concept understanding (PK)	True	CRI > 1,5	True	CRI > 1,5

RESULTS AND DISCUSSION

Validity and Reliability of the Four-Tier Diagnostic Test Instrument

Before doing the research, the four-tier diagnostic test instrument was tested on students other than the sample to determine its validity and reliability. The validity that was carried out included the validity of the construct and the validity of the items. The validity of the construct was carried out using expert opinion. The validated instrument was a diagnostic test instrument. The results of the four-tier diagnostic test instrument contract validation can be seen in Table 2.

Table 2 Results of Contract Validity

Validator Code	Mean Score	Conclusion
VT-1	3,8	Valid questions and can be used after repairs have been made

The four-tier diagnostic test instrument was declared to be very valid by the validator. This diagnostic test instrument can be used for research with a mean score of 3.8 which is included in the valid criteria. This four-tier diagnostic test instrument also fulfills the criteria for reliability with the results of the reliability test analysis of 0.85.

Profile of Students Misconceptions

Students' misconception profiles are categorized based on the combination of answers given by students. The profile of student misconceptions consists of 4 categories, namely Misconception (Mi), Concept Understanding (PK), Concept Misunderstanding (TP), and Error (E). The results of the student's misconception profile can be seen in Figure 1.
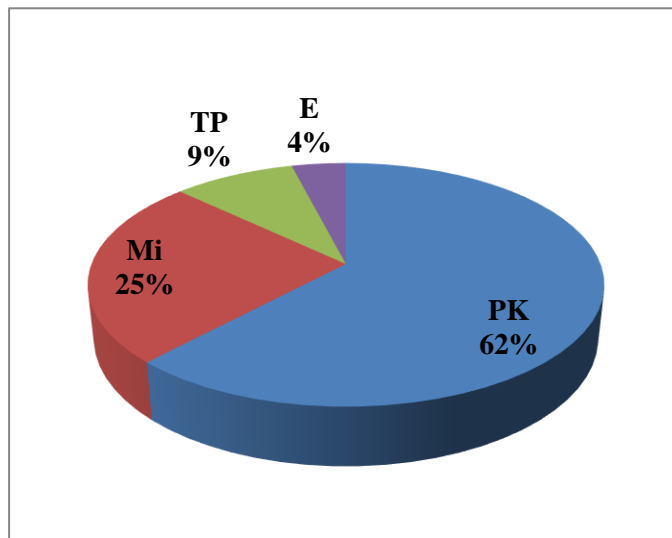
Figure 1 Profile of student

Based on Figure 1, the percentage of student misconceptions is 25%. This figure shows that students' misconceptions fall into the low category. The total percentage of students who understand the concept of 62% can be categorized as high Tier. The percentage of students who do not understand is 9% and an error of 4% can be categorized as low Tier.

The highest profile of student misconceptions was in item number 20. Students who experienced misconceptions on item 20 were 74% or 106 students out of a total of 143 students. Item number 20 is a C5 level question. This item asks students to conclude a case of abnormality in the form of numbness in the hand with damage to one of the parts of the body associated with the disorder.

Based on the case presented, the numbness that occurs in the hand is related to the nerves in the spine that regulate the upper limb, including the hand. The spine that regulates the upper extremities is the thoracic. A snippet of question number 5 is presented in Figure 2.

Figure 2 Question Number 20

The misconceptions that occurred in item number 20 included (1) students assumed that the lumbar spinal cord was what controlled the hands or upper extremities, while the thoracic regulates the head, and (2) students assumed that the brain was the controller of all movements in the body. Both of these assumptions are incorrect because the numbness of the hand is caused by damage to the nerves in the thoracic spinal cord. This thoracic part regulates the upper extremities. The lumbar part regulates the lower extremities. The cervix regulates the neck.

There are 4 types of answer combinations that fall into the misconception category which is described in Table 3.

Table 3 Misconception Answers Combination

	Answer Combination			
	Answer (Level 1)	Answers CRI (Level 2)	Reasons (Level 3)	Reasons CRI (Level 4)
Type 1	True	CRI > 1,5	False	CRI > 1,5
Type 2	True	CRI < 1,5	False	CRI > 1,5
Type 3	False	CRI < 1,5	False	CRI > 1,5
Type 4	False	CRI > 1,5	False	CRI > 1,5

Basic Competency Indicators (IKD) on regulatory system material include (1) linking the structure and function of the organ making tissue to the human coordination and regulatory system (nerves, hormones, and sensory organs), (2) analyzing the relationship of the tissue structure of organs in the coordination system and regulation with its mechanism, (3) analyzing the stimulation delivery mechanism in the human coordination and regulatory system organs, and (4) diagnosing abnormalities and disorders of the human coordination and regulatory system.

The highest profile of student misconceptions was found in IKD-1, which was 35%, the highest profile of conceptual understanding was shown in IKD-2 which was 82%, the highest profile

did not understand the concept of IKDI-1, which was 5%, and the highest error profile was shown in IKD-4 which is equal to 1%. The profile of student misconceptions at each IKD is presented in Figure 3.
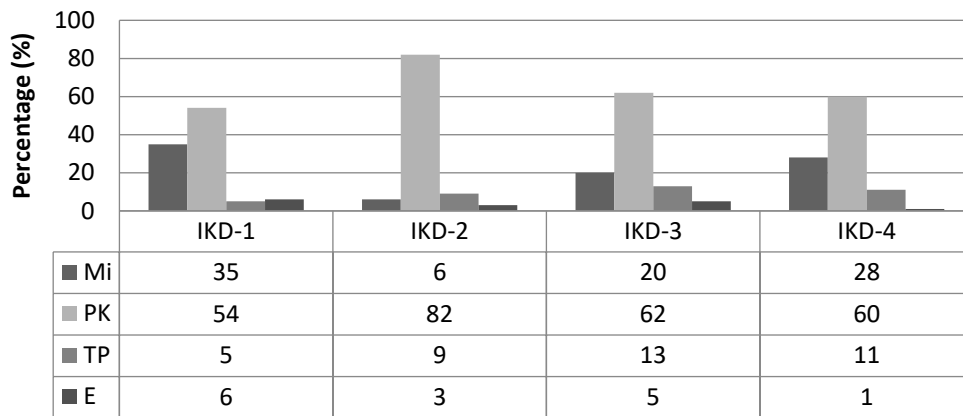

	IKD-1	IKD-2	IKD-3	IKD-4
Mi	35	6	20	28
PK	54	82	62	60
TP	5	9	13	11
E	6	3	5	1

Figure 3 Profile of Students' Concept Understanding of Each IKD

The highest profile of student misconceptions in IKD-1 is in item number 9. Item number 9 is a C5 level question which presents a case about one of the rules in sports, namely not allowing participants to hit the answer on the back of the head, students are asked to express their opinion, agree or not, and analyze the reasons associated with the structure of the brain. Snippets of item 9 are presented in Figure 4.

Figure 4 Question Number 9

There were 68% students who experienced misconceptions in item 9 or 96 out of a total of 143 students. The misconceptions that occur include (1) students assume that behind the head there are important nerves that will affect if they are hit and damaged, namely the circulatory nerves, and (2)

students think that on the back of the head there are blood vessels that carry oxygen and helps smooth the work of nerves so that when hit and damaged it will interfere with the flow of oxygen and nerves. Both of these assumptions are wrong, because at the back of the head there is the medulla oblongata as the center for regulating the work of vital organs, which when hit by a blow will experience damage and affect the vital organs which will cause fainting and even death.

The highest profile of student misconceptions in IKD-2 is in item number 15. In item number 15, as many as 10% or 14 students out of a total of 143 students experience misconceptions. Item number 15 is a C5 level question. Students are asked to predict which cranial nerves will affect which is associated with the coordination and regulatory system mechanisms of a presented case. From 12 pairs of cranial nerves, students were asked to predict which one of the cranial nerves would cause hearing abnormalities. A snippet of question number 15 is presented in Figure 5.

15. Anak yang baru dilahirkan oleh bu Lina divonis dokter mengalami gangguan pada indra pendengarannya. Menurut dokter, terdapat kerusakan pada saraf indra pendengarannya. Kemungkinan saraf yang dimaksud adalah ....
   a. **Saraf vestibulokoklear (CN VII)**
   b. Saraf fasial (CN VII)
   c. Saraf optik (CN II)
   d. Saraf olfaktori (CN I)
   e. .... (alasan lain)

Apakah Anda yakin dengan jawaban Anda?

0	1	2	3
Menebak	Tidak yakin	Yakin	Sangat yakin

Alasan:
   a. Saraf optik menyampaikan persepsi indra pendengaran
   b. Saraf olfaktori menyampaikan persepsi indra pendengaran
   c. **Saraf vestibulokoklear menyampaikan informasi dari indra pendengaran ke talamus dan lobus temporal otak**
   d. Saraf fasial menyampaikan informasi dari indra pendengaran ke lobus temporal otak
   e. .... (alasan lain)

Apakah Anda yakin dengan jawaban Anda?

0	1	2	3
Menebak	Tidak yakin	Yakin	Sangat yakin

Figure 5 Question Number 15

Misconceptions in item 15 belong to the low category, namely 10%. Based on the results of the interview, the misconceptions that occurred in students were because the language was still foreign, so that students had difficulty understanding the names of cranial nerves. Students' interest in learning which tends to be low coupled with a language that is still foreign to sound causes students to experience misconceptions even though it is classified as low on this item. The highest profile of student misconceptions in IKD-3 was found in item 17. Students who experienced misconceptions in item 17 were 68% or 97 of the total 143 students. Item number 17 is a C5 level question that asks students to analyze the receptors that affect it and relate it to the stimulation delivery mechanism according to the desire presented in the questions. In the case in question, husband can smell the wife's cooking aroma from a distance because he has olfactory chemoreceptor receptors located on the olfactory epithelium in the ceiling of the nasal cavity. For the choice of reason, students are asked to link the receptor to the nasal impulse delivery mechanism. Snippets of item 17 are presented in Figure 6.

17. Ibu memasak cumi di dapur. Dari ruang tamu, Bapak dapat mencium aroma sedapnya masakan Ibu. Apa yang mempengaruhinya?
    a. Kemoreseptor optik
    b. **Kemoreseptor olfaktori**
    c. Mekanoreseptor
    d. Termoreseptor
    e. .... (alasan lain)

Apakah Anda yakin dengan jawaban Anda?

0	1	2	3
Menebak	Tidak yakin	Yakin	Sangat yakin

Alasan:
   a. Berfungsi menerima rangsang berupa bau dengan mekanisme: gas masuk ke hidung → merangsang silia sel reseptor → larut pada selaput mukosa → rangsangan diteruskan ke otak untuk diolah → jenis bau dapat diketahui
   b. **Berfungsi menerima rangsang berupa bau dengan mekanisme: gas masuk ke→ larut pada selaput mukosa → merangsang silia sel reseptor → rangsangan diteruskan ke otak untuk diolah → jenis bau dapat diketahui**
   c. Berfungsi menerima rangsang berupa bau dengan mekanisme: gas masuk ke hidung → merangsang silia sel reseptor → larut pada epitelium olfaktori di langit-langit hidung → rangsangan diteruskan ke otak untuk diolah → jenis bau dapat diketahui
   d. Berfungsi menerima rangsang berupa bau dengan mekanisme: gas masuk ke hidung → larut pada epitelium olfaktori di langit-langit hidung → merangsang silia sel reseptor → rangsangan diteruskan ke otak untuk diolah → jenis bau dapat diketahui
   e. .... (alasan lain)

Apakah Anda yakin dengan jawaban Anda?

0	1	2	3
Menebak	Tidak yakin	Yakin	Sangat yakin

Figure 6 Question Number 17

The misconception that often occurs in students is that the explanation in the book is different from the choices provided in the questions. Some students when interviewed explained that the sequence of the nasal impulse delivery mechanism described in the student handbook and the one provided in the choice of questions was slightly different, causing confusion. The way some students learn before working on this four-tier diagnostic test is by having a discussion with their friends and looking for other sources from the internet, but when working on item 17 there is a difference in the mechanism for delivering impulses to the nose. The explanation of the nasal impulse delivery mechanism in the student handbook is more complex than in the question choices presented.

CONCLUSION

The four-level diagnostic test instrument can be used to analyze student misconceptions by analyzing the combination patterns of students' answers. The results of the analysis show that 25% of the students' misconceptions of SMA Negeri 2 Semarang students about the regulation system material are in the low category. Of the 4 types of combination answers that fall into the misconception category. In general, the causes of student misconceptions are student prejudice, lack of literature, and lack of time to study.

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