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Development of a Diagnostic Test Based on Three-Tier Multiple Choice to Identify Student Misconceptions on Circulatory System Material

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Abstract

This research is a research and development (R&D) type formative research Tessmer which aims to develop a three-tier multiple choice diagnostic test that can identify student misconceptions on circulatory system material. The product development stage consists of two stages, namely the preliminary stage and formative evaluation (self evaluation, prototyping). The subjects in this study were students of class XI MIPA SMAN 10 Bone. Based on the results of the study, it can be concluded that the final prototype or final product of the three-tier multiple choice diagnostic test instrument developed as a whole is included in good quality in terms of validity, reliability, level of difficulty and differentiation. Based on the results of the analysis, it shows that the three tier multiple choice diagnostic test instrument is successful and effective in identifying student misconceptions on circulatory system material with the percentage of students who experience misconceptions is 38.6%.

Keywords: *Circulatory System; Diagnostic Test; Misconceptions; Three-Tier Multiple Choice*

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INTRODUCTION

Concept understanding is the ability of students to understand learning material and apply it in everyday life. Understanding concepts is very important in teaching and learning activities and is the basis for achieving maximum learning outcomes. A complex concept can only be mastered properly and correctly if the underlying concept is also good and correct (Izza et al., 2021). Students who have difficulty understanding concepts will provide their own interpretations as a result of reconstructing prior knowledge with new knowledge, where the results of these interpretations may not be in accordance with the

concepts that have been conveyed by experts so that they can cause students to experience concept errors or misconceptions (Khairaty et al., 2018). Misconception can be interpreted as an idea owned by someone different from the concept that has been agreed upon by experts or experts (Afifah & Asri, 2020).

Science misconceptions can be defined as students' opinions derived from their everyday or unstructured experiences, which are not precisely organized, leading to misunderstandings and not consistent with a scientific idea (Soeharto et al., 2019). Studying, including studying biology is rife with misconceptions. The causes of misconceptions are categorized by Irawan (2021); Rambe & Ulfa (2022) as teachers, students, textbooks, context, and learning methodologies.

Misconceptions in Biology caused by students include low cognition, critical thinking skills, scientific literacy and science process skills. Students' low cognition is related to interest and motivation to learn. Adnan et al., (2019) explained that students who have high learning motivation tend to have high cognitive abilities and vice versa, students who have low learning interest and motivation tend to have low cognition.

Apart from students, misconceptions can also come from teachers. Misconceptions originating from teachers can be caused by several things. The teacher does not master the materials or material that will be taught in class. Aldi et al., (2022) explain that teaching materials are things that contain information and knowledge that can be utilized and studied by its users. Arifuddin et al., (2019) stated that learning materials have a very important role and are part of the entire curriculum so teachers must prepare lesson materials so that the goals that have been set can be achieved.

The teaching method is dominated by lectures and writing and does not correct students' assignments. Maknun et al., (2018) stated that teachers have an important role in improving education quality so that teachers must carry out learning planning, choose various learning models, interesting learning media and good evaluation tools. Hala et al., (2018) revealed that the use of textbooks available in schools and used by teachers and students in the teaching and learning process can also cause misconceptions, where the material contained in these textbooks is concise and the language is difficult to understand.

Ilmi et al., (2020) explain that the blood circulatory system has material with high complexity, abstract sub-topics such as the characteristics of each blood cell, and there are many organs involved and mutually continuous processes become the reason why students have difficulty understanding the circulatory system material. These things often make students misunderstand the material, thus allowing misconceptions to occur.

Misconceptions that occur in students cannot be left alone because they can affect students' understanding of subsequent concepts (Mujib, 2017; Muryani et al., 2022). Diagnostic tests are tools that can be used to find misconceptions. Diagnostic tests are designed to identify students' learning strengths and weaknesses so that the results can be utilized to tailor follow-up instruction to the students' areas of difficulty and in line with their mistakes (Widiyana et al., 2019).

One-tier, two-tier, three-tier, and four-tier diagnostic tests are the several tiers of multiple choice diagnostic tests (Nurulwati & Rahmadani, 2020). One sort of diagnostic test that can be used to find misconceptions that students may have about particular subject during the learning process is the three-tier multiple-choice diagnostic test.

The three-tier multiple choice diagnostic test is a refinement of the one-tier and two-tier diagnostic tests. This is in line with the opinion of Mubarak et al., (2016) who revealed that the three-tier multiple-choice diagnostic test was developed from the two-tier multiple choice diagnostic test. The development is found in the addition of the level of confidence of students in choosing answers and the reasons given. Gurel et al., (2015) explain that the three tier multiple choice consists of the first level in the form of ordinary multiple-choice tests, the second level in the form of multiple-choice test questions that ask why, and the third level in the form of a scale that asks the level of confidence of students in the answers given.

Comparing the three-tier diagnostic test instrument to the one- and two-tier versions, Sencar et al., (2005) noted that the three-tier test instrument is a legitimate, accurate, and reliable means of identifying misconceptions. An additional benefit of the three-tier multiple-choice diagnostic test is its ability to discern between students who comprehend topics, have misconceptions about them, lack information, or do not understand concepts at all.

Based on research by Khairaty et al., (2018) regarding the identification of misconceptions in circulatory system material, it shows that there are 56.21%. The research results of Wahyuni et al., (2020) also show that the percentage of students who experience misconceptions about the circulatory system material is 22.00%. Based on the background explained previously, it is important to identify and prevent misconceptions in students so that they do not hinder the subsequent learning process, and looking at the results of related research which also shows that the level of misconceptions is still high, it is necessary to develop another instrument to identify misconceptions, namely a diagnostic test based on three-tier multiple choice in circulatory system material.

METHOD

The type of research used is research and development (R&D) with a formative research type development model (Tessmer, 1993; Akker et al., 2006). The study's output is a three-tier multiple-choice diagnostic test designed to identify students' misconceptions about concepts related to the circulatory system.

The product development stage consists of two stages, namely the Preliminary and formative evaluation stages. Preliminary is an assessment of several reference sources related to research. Formative evaluation which includes self evaluation and prototyping stages (expert reviews, one-to-one, small group and field test). The research was conducted at SMA Negeri 10 Bone on October 9-14, 2023. 3 students of class XI MIPA 1 became the subject of the one-to-one trial, 6 students of class XI MIPA 2 and XI MIPA 4 became the subject of the small group trial. The field test research subjects were 26 students of class XI MIPA 3.

The data collection method consists of test and documentation methods. The data analysis carried out included validity analysis, namely content validity and empirical validity, reliability analysis, level of difficulty, differential power and interpretation of the results of the three tier multiple choice diagnostic test. Validity testing consists of content validity using the content validity coefficient formula Aiken's V, as follows:

$$V = \frac{\sum s}{n(c-1)}$$

Detail :
s = r-lo
lo= lowest assessment number (1)
c= highest assessment number (5)
r=number given by the assessor
n=number of subject matter experts

Table 1. Validity Based on Aiken Scale (Afifah & Yusmaita, 2019)

Aiken Scale V	*Validity*
0,80<V	Valid
0,40<V≤0,80	Moderate
V≤0,40	Less

Empirical validity test uses biserial correlation coefficient. After obtaining the biserial correlation coefficient (Ypbl) value, it is then compared with the r results in the table with a significance level of 5%. The question item criteria are said to be valid if the rcount table> rtable. In the field test stage, apart from the validity test, several other analyzes are also carried out, namely reliability analysis, level of difficulty and different power to determine the quality of the questions. Reliability analysis is calculated with KR20 in the Microsoft Excel program, the closer it is to 1, the more reliable it is. Reliability analysis uses the following formula:

$$r11 = \left(\frac{k}{k\text{-}1}\right)\left(\frac{V_{t-\sum PQ}^2}{V_t^2}\right)$$

Detail :
r11=instrument reliability
k = number of questions
Vt = total score variance
p = proportion of correct answers to a particular item
q = proportion of wrong answers on a particular item

The level of difficulty is the percentage of subjects, in this case students who answer correctly and precisely. The formula for finding the level of difficulty is:

$$P = \frac{B}{JS}$$

Detail :
P = difficulty index
B = the number of students who answered the question correctly
JS = total number of students taking the test

Table 2. Difficulty Index Classification (Arikunto, 2015)

Difficulty Index (P)	*Category*
0,00-0,30	Hard
0,31-0,70	Currently
0,71-1,00	Easy

To analyze the differentiating power of each question item, the following formula can be used:

$$D = \frac{BA}{JA} - \frac{BB}{JB} = PA - PB$$

Detail :
JA = number of participants in the upper group
JB = number of lower group participants
BA = the number of participants in the upper group who answered the question correctly
BB = the number of lower group participants who answered the question correctly
PA = proportion of upper group participants who answered correctly
PB = proportion of lower group participants who answered correctly

Table 3. Differential Power Criteria (Arikunto, 2015)

Differential Power Index	*Item Criteria*
0,00 ≤ D < 0,20	Weak
0,20 ≤ D < 0,40	Enough
0,40 ≤ D < 0,70	Good
0,70 ≤ D≤ 1,00	Very good

Analysis of students' understanding profile using the answer combination pattern given by Elvia et al., (2021) adaptation of Arslan et al., (2012).

Table 4. Interpretation of Three Tier Multiple Choice Diagnostic Test Results

First Tier	**Second Tier**	**Third Tier**	**Criteria**
Correct	Correct	Certain/ Very certain	Scientifif knowledge
Correct	Incorrect	Certain / Very certain	Misconception
Incorrect	Correct	Certain / Very certain	Misconception
Incorrect	Incorrect	Certain / Very certain	Misconception
Correct	Correct	Uncertain	Lack of knowledge
Correct	Incorrect	Uncertain	Lack of knowledge
Incorrect	Correct	Uncertain	Lack of knowledge
Correct	Incorrect	Guessing	Lack of knowledge
Incorrect	Incorrect	Guessing	Lack of knowledge

The following formula is used to analyze the percentage of students who have misconceptions about each sub-material:

$$\text{Percentage } (\%) = \frac{f}{N} \times 100\%$$

Detail :
P = percentage of students per category
f = number of students per category
N = the total number of students who are research subjects

RESULTS AND DISCUSSION

The diagnostic test developed is not to assess learning outcomes but aims to reveal students' misconceptions. The diagnostic test developed in this study is a three tier multiple choice diagnostic test, namely a multiple choice diagnostic test made at 3 levels

with the number of initial questions, namely prototype I, totaling 22 question items. The diagostic test developed was analyzed to determine the validity and reliability values.

According to Afifah & Asri (2020), an instrument's validity is determined by how accurately it measures the target variable. The content validity and empirical validity constitute the carried out validity. Using the Aiken V formula, the validity of the content verified by two validators is determined. Table 5 displays the content validity analysis results.

Table 5. Content Validity Analysis of Three-Tier Multiple Choice Diagnostic Test Instrument

Item	V	Decision
1	0,89	Valid
2	0,88	Valid
3	0,93	Valid
4	0,88	Valid
5	0,91	Valid
6	0,81	Valid
7	0,90	Valid
8	0,91	Valid
9	0,90	Valid
10	0,89	Valid
11	0,85	Valid
12	0,88	Valid
13	0,85	Valid
14	0,95	Valid
15	0,86	Valid
16	0,84	Valid
17	0,90	Valid
18	0,80	Valid
19	0,89	Valid
20	0,85	Valid
21	0,86	Valid
22	0,86	Valid
Average	**0,91**	**Valid**

Based on the Aiken V formula, a test has content validity if 0.80<V with a valid decision. Meanwhile, if 0.40<V<0.80, then the validity decision is in the medium category. Table 3 is the results of content validity, twenty-two questions have a validity value above 0.80 in the valid category. The average validity value for the questions as a whole is 0.91 in the valid category.

The next stage is empirical validity analysis. After being validated by validators or subject experts matter, prototype I consisting of 22 questions was tested on students and calculated empirical validity values analyzed using biserial correlation coefficients.

The criteria for a question item are said to be valid if rcalculate > rtable.. The questions used for the next stage are only valid questions. The one-to-one trial was carried out on October 10, 2023 in class XI MIA 1 as many as 3 students and the test results were obtained that there were 6 invalid questions because < 0.997 (r table). Invalid questions were eliminated and 16 valid questions were rearranged into prototype II.

The small group trial (prototype II) was tested on October 12, 2023 in class XI MIPA 2 and MIPA 4 as many as 6 students and obtained test results that there was 1 invalid question because it was < 0.811 (r table). Invalid questions were eliminated and 15 valid questions were rearranged into prototype III. The field test (prototype III) was tested on October 13, 2023 in class XI MIA 3 as many as 26 students and obtained test results that there was 1 invalid question because it was < 0.388 (r table).

Table 6. Test Difficulty Results

Item	Difficulty Index	Ctiteria
1	0,54	Keep
2	0,42	Keep
3	0,12	Difficult
4	0,58	Keep
5	0,46	Keep
6	0,38	Keep
7	0,69	Keep
8	0,19	Difficult
9	0,38	Keep
10	0,38	Keep
11	0,19	Difficult
12	0,23	Difficult
13	0,15	Difficult
14	0,12	Difficult
15	0,27	Difficult

Test the reliability of the three-tier multiple choice diagnostic test instrument using KR-20 in the Microsoft Excel program. The closer to 1, the more reliable. The results of the analysis showed that reliability was 0.63. Based on the results of the level calculation in table 2 (Arikunto, 2015). The results of the difficulty level analysis for each test question item with recapitulation are presented in table 6.

Based on Table 6, it can be seen that the difficulty level of the question items for medium criteria includes questions number 1, 2, 4, 5, 6, 7, 8, 9 and 10. While the question items for difficult criteria include questions number 3, 8, 11, 12, 13, 14 and 15. Based on the results of the calculation of differentiating power with 4 categories in table 3 (Arikunto, 2015). The results of the differentiating power analysis for each test question item with recapitulation are presented in table 7.

Based on Table 7, it can be seen that the distinguishing power of the question items for the criteria is very good, including question number 2. Question items with good criteria include questions number 4, 6, 10, and 12. Question items with sufficient criteria

include questions number 1, 5, 7, and 9. Question items with weak criteria include questions number 3, 8, 11, 13, 14 and 15. Based on the results of the analysis at the field test stage, an overview of the understanding of the concept of students XI Science 3 SMA Negeri 10 Bone on the concept of the circulatory system is shown in table 8.

Table 7. Power Difference Test Results

Item	Differentiation Power Index	Ctiteria
1	0,3	Enough
2	0,8	Very good
3	0,1	Weak
4	0,5	Good
5	0,3	Enough
6	0,5	Good
7	0,2	Enough
8	0,1	Weak
9	0,3	Enough
10	0,6	Good
11	0,1	Weak
12	0,5	Good
13	0,1	Weak
14	0	Weak
15	0,1	Weak

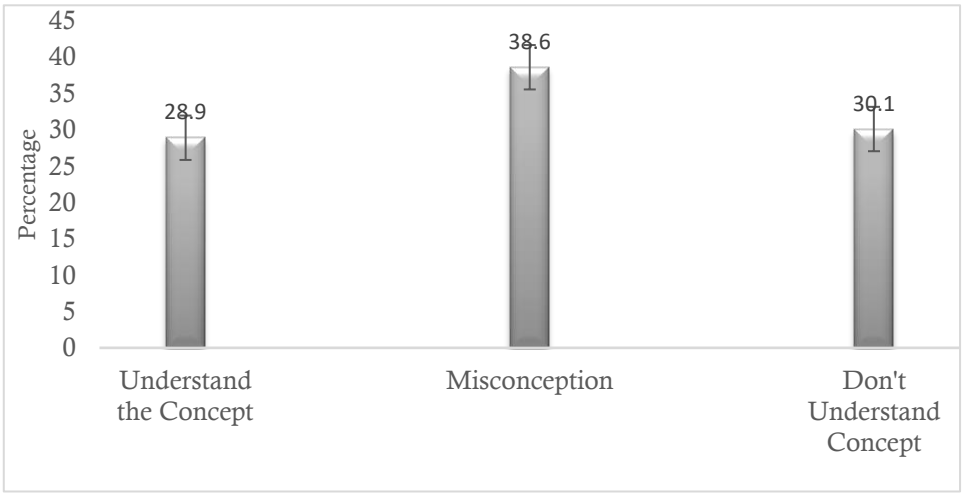

Figure 1. Comparison of Learners' Overall Comprehension (Percentage)

Based on Figure 1, data on the percentage of grouping students in the categories of understanding concepts, misconceptions, and not understanding concepts were obtained. The highest percentage is found in the misconception category of 38.6%, do not understand the concept by 30.1% and the percentage of students who have understood the concept is almost the same as students who do not understand the concept which is 28.9%.

Table 8. Result of Student Understanding Based on Subconcepts in Circulatory System Material

Sub concepts	Item	Criteria					
		Understand the Concept		**Misconception**		**Don't Understand Concept**	
		Sum Participants educate	%	Sum Participants educate	%	Sum Participants educate	%
Blood components	1	14	3,8	5	19,2	7	26,9
	2	11	42,3	8	30,7	7	26,9
	3	2	7,6	16	61,5	8	30,7
	4	15	57,6	10	38,4	1	3,8
	$\bar{X}$		**29,6**		**37,4**		**22,0**
Bioprocesses of the circulatory system	5	2	46,1	8	30,7	6	23,0
	6	10	38,4	11	42,3	5	19,2
	7	15	57,6	6	23,0	5	19,2
	$\bar{X}$		**47,3**		**32**		**20,4**
Circulatory organs	8	5	19,2	11	42,3	10	38,4
	9	10	38,4	10	38,4	6	23,0
	10	10	38,4	11	42,3	5	19,2
	$\bar{X}$		**32,0**		**41,0**		**26,8**
Circulatory mechanism	11	5	19,2	9	34,6	12	46,1
	12	4	15,3	8	30,7	14	53,8
	13	4	15,3	3	50	9	34,6
	$\bar{X}$		**16,6**		**38,4**		**44,8**
Circulatory system disorders	14	3	11,5	10	38,4	13	50
	15	7	26,9	13	50	6	23,0
	$\bar{X}$		**19,2**		**44,2**		**36,5**
Average		**28,9 %**		**38,6 %**		**30,1 %**	

This data on figure 1 shows that students who experience misconceptions are higher than students who do not understand or students who understand concepts. The percentage of student misconceptions based on subconcepts in circulatory system material is presented in figure 2.

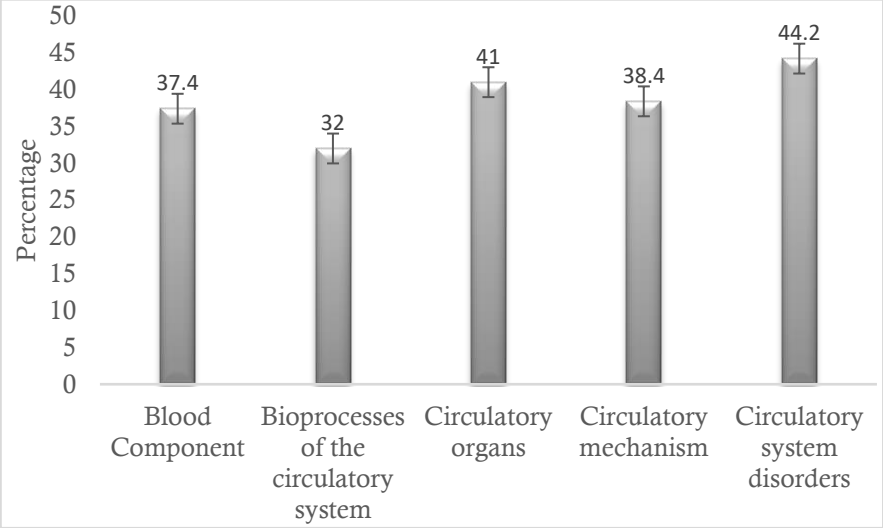

Figure 2. Graph of the misconceptions of students based on the subconcept of circulatory system material

The data shows that the percentage of misconceptions occurring in sub-matter varies. The percentage of misconceptions of each sub-material can be seen in figure 2. The largest percentage of misconceptions is found in the sub-concept of circulatory system disorders with a percentage of 44.2%, The second is the circulatory organ with a percentage of 41%, the third subconcept of circulatory mechanism with a percentage of 38.4%, the fourth subconcept of blood components with a percentage of 37.4% and the fifth subconcept of circulatory system bioprocesses with a percentage of 32%. A general description of student misconceptions on circulatory system material can be seen in table 9.

The subconcept of blood components discusses the constituent components, structure and function of blood components. Students who experienced misconceptions in this subconcept amounted to 37.4%. The percentage of misconceptions is higher than that of students who understand or do not understand concepts. The high percentage of misconceptions indicates that learners have been unable to precisely explain the constituent components of blood, function, structure and concentration of erythrocytes in two different areas. Based on the pattern of answers of students who experience misconceptions, students assume that granulocyte leukocytes consist of monocytes, lymphocytes, eosinophils should granulocyte leukocytes consist of neutrophils, basophils and eosinophils. Learners have not been able to categorize granulocyte leukocytes and agranulocytes. Granulocytes (having granules) include neutrophils, eosinophils, and basophils. Granulocytes have a cell nucleus with several lobes (polymorphonuclear).

Agranulocytes (without granules) consist of monocytes and lymphocytes, each of which has a cell nucleus consisting of only 1 lobe (Andria et al., 2022).

Table 9. Overview of Student Misconceptions on Circulatory System Material

Subconcept	Misconceptions	True Concept
Blood Components	Granulocyte leukocytes consist of monocytes, lymphocytes, eosinophils	Granulocyte leukocytes consist of neutrophils, basophils and eosinophils.
	The concentration of red blood cells in the lowlands is greater than in the highlands	The concentration of red blood cells in the lowlands is less than in the highlands (red blood cells in the highlands are more)
Circulatory System Bioprocesses	Blood type O+ can donate blood to all blood types	Blood type O+ can only donate blood to rhesus positive (+) recipients
Circulatory organs	The thickest heart muscle is found in the left porch (atrium) because it is related to its function as a blood pump throughout the body	The thickest heart muscle is found in the left ventricle because it is related to its function as a blood pump throughout the body
Circulatory Mechanism	The blood circulation that transports a lot of carbon dioxide starts from the pulmonary artery-right ventricle-right atrium-vena cava-body tissues.	Blood circulation that transports a lot of carbon dioxide begins Body tissue-vena cava-right atrium-right ventricle -pulmonary artery
Circulatory System Disorders	*Erythroblastosis fetalis* occurs because the mother and father have the same group and rhesus	*Erytroblastosis fetalis* can occur in infants if the mother with rhesus negative gives birth to a baby from a father who is rhesus positive

In addition, another highest misconception in this subconcept is that students assume that oxygen levels in the lowlands are less because of the hot air temperature that requires many erythrocytes. The concentration or level of erythrocytes in the lowlands should be less than in the highlands (erythrocytes in the highlands are more). This is related to the existence of the earth's gravitational force factor that arises. Gravity in the lowlands becomes higher because of its proximity to the earth's core, while the higher an area, the farther away from the center of the earth so that the weaker the gravitational force. This weak gravity causes air pressure to become weaker as well. Low pressure will cause oxygen pressure at high altitudes to be low, requiring more hemoglobin in erythrocytes to help the process of oxygen binding.

This is relevant to the results of research by Bahri et al., (2022) that highland residents have higher hemoglobin levels with an average value of 14.69 g / dL while

residents in the lowlands on average have hemoglobin levels of 13.14 g / dL. The difference is caused by the weakening of the gravitational force due to rising altitude which has an impact on the low partial pressure of highland O2 compared to the partial pressure of lowland O2. The decrease in partial pressure of O2 is responded by the body by acclimatizing through increased hemoglobin synthesis in erythrocytes. The results of the study of Al-Sweedan & Alhaj (2012) also revealed that the average value of hemoglobin, average blood cell volume and hematocrit was higher in people living at high altitudes.

The subconcept of circulatory system bioprocesses discusses blood type, blood transfusion and blood clotting. In this subconcept, the percentage of students who understand the concept is higher (47.3%) compared to students who experience misconceptions at 32%. The high percentage of understanding the concept shows that students are able to determine blood type, transfusion and explain the process of blood clotting. Even so, some students still have difficulty in determining the blood cells that initiate the process of blood clotting and blood transfusion. The highest misconception in this subconcept is that students assume that O+ blood types can donate blood to all blood types, O+ blood types should only be able to donate blood to rhesus positive (+) recipients as well. Reswari et al., (2022) explained that any blood type with Rh positive can receive blood transfusions of the same blood type as Rh positive or negative. Meanwhile, a person with a Rhesus negative blood type can only get blood from the same blood type. Avent & Reid (2000) also add that recipients will receive D-negative (Rh negative) red blood cell products from donors who also have Rh negative.

The subconcept of circulatory organs discusses the parts of the heart and their functions. Students who experience misconceptions in this subconcept are 41%. The percentage of misconceptions is higher than students who understand concepts and do not understand concepts. The high percentage of misconceptions shows that students have not been able to determine the parts of the heart and their functions precisely in the circulatory process. This subconcept has many scientific terms, making it difficult for students to remember the main material that determines the scientific name of the heart chamber. The highest misconception in this subconcept is to assume that the part of the heart that pumps blood throughout the body is the left atrium so that the muscles in that part of the heart are thicker. The part of the heart that pumps blood throughout the body should be the left ventricle. Kadir (2009) explains that the left heart pumps blood to a wider systemic circulation and has high resistance, while pulmonary circulation has low resistance. Therefore, the left ventricular muscle is thicker.

The circulatory mechanism subconcept discusses the mechanism of large blood circulation, small blood circulation, and the flow of the circulatory process that contains a lot of carbon dioxide. In this subconcept, the percentage of students who do not understand the concept is higher at 44.8%, compared to students who understand the concept or who experience misconceptions at 38.4%. Students' lack of confidence has an effect on the high percentage not understanding concepts. This is in line with research conducted by Abraham in Mubarak et al (2016) that students who show insecurity because of students' weak understanding of the material that has been taught. The highest misconception in this subconcept is that students assume that the blood flow that transports a lot of carbon dioxide starts from the pulmonary artery, right ventricle, right

atrium, vena cava, body tissues. It should start from the tissues of the body, vena cava, right atrium, right ventricle, pulmonary artery. This is in accordance Zhu (2009) with research that systemic blood circulation, blood will take carbon dioxide and the results of the body's metabolism to then be brought back to the heart through the right porch.

The subconcept of circulatory system disorders discusses abnormalities in the circulatory system based on their characteristics and causes. Students who experienced misconceptions in this subconcept amounted to 44.2%. The percentage of misconceptions is higher than that of students who understand or do not understand concepts. The high percentage of misconceptions indicates that students have not been able to explain and determine the cause of abnormalities in the circulatory system. The highest misconception in this subconcept is that students assume that fetalis erythroblastosis abnormalities are caused because the parents of the baby have the same rhesus. Erythroblastosis fetalis can occur in infants if a rhesus-negative mother gives birth to a rhesus-positive father. So, such abnormalities can occur due to ABO incompatibility and Rh incompatibility. This is relevant to the research of Nagamuthu et al., (2016) that in pregnancy, women with D-Negative (Rh negative) whose husbands choose Rh positive require guidance during the antenatal period to minimize the occurrence of cases of hemolytic disease or erythroblastosis fetalis in newborns.

CONCLUSION

The diagnostic test instrument developed in the form of three tier multiple choice (three tier multiple choice) by following the stages of development of the formative research type Tessmer consists of two stages, namely the Prelimenary stage and the Formative evaluation stage which includes the self-evaluation stage, Prototyping (expert reviews, one-to-one and small groups and field tests. Test instruments that are developed as a whole are included in good quality in terms of validity, reliability, differentiating power and level of difficulty. It was seen that the diagnostic test developed was able to detect the occurrence of student misconceptions on circulatory system material, the percentage of students who experienced misconceptions was 38.6%. The largest percentage of misconceptions is found in the sub-concept of circulatory system disorders with a percentage of 44.2%, the second is the circulatory organ with a percentage of 41%, the third is the circulatory mechanism subconcept with a percentage of 38.4%, the four subconcepts of blood components with a percentage of 37.4% and the fifth subconcept of circulatory system bioprocesses with a percentage of 32%.

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