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PROFILE OF MISCONCEPTION ON GENETIC SUBSTANCE TOPIC ON STUDENT GRADE XII WITH FOUR-TIER DIAGNOSTIC TEST

Profil Miskonsepsi Materi Substansi Genetika pada Siswa Kelas XII dengan Four-Tier Diagnostic Test

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Abstract

One of the obstacles that occur in the learning process is a misconception, inappropriate understanding of concepts. The misconceptions experienced by each student in one class can be different from one another and are caused by various causes. This study aims to describe the profile of misconceptions experienced by students and the causes of misconceptions in students. This research is descriptive quantitative. The research stage began with the making of a diagnostic test instrument (Four-Tier diagnostic test) which was then validated by a material and education expert. Then, the instrument was tested on grade XII student to collect the data. The data were analyzed descriptively. The target of this research was students of MAN 2 Gresik with a total of 60 students. The results showed the profile of students' misconceptions on Genetic Substance material consisting of the concepts of RNA, DNA, chromosomes, DNA & chromosome gene relationships, protein synthesis, and DNA replication with the category of understanding the concept amounted to 6.1%, 39.9% understand some concepts, 41.8% students experience misconceptions, and 12.2% do not understand concepts. The factors that cause misconceptions consist of students, textbooks, learning media, and teaching methods. Further studies of the development and implementation of digital-based learning media on genetic substance material, should be done near the future to reduce student misconceptions.

Keywords: *genetic substance, misconceptions, four-tier diagnostic test*

Abstrak

Salah satu hambatan yang terjadi dalam proses pembelajaran adalah miskonsepsi, pemahaman konsep yang tidak tepat. Miskonsepsi yang dialami setiap siswa dalam satu kelas bisa berbeda satu dengan yang lain dan disebabkan oleh berbagai penyebab. Penelitian ini bertujuan untuk mendeskripsikan profil miskonsepsi yang dialami siswa dan penyebab terjadinya miskonsepsi pada siswa. Penelitian ini bersifat deskriptif kuantitatif. Tahapan penelitian dimulai dari pembuatan instrumen tes diagnostik (Four-Tier diagnostic test) yang kemudian divalidasi oleh dosen ahli materi dan pendidikan. Selanjutnya instrumen diuji coba pada siswa kelas XII untuk mengumpulkan data. Data dianalisis secara deskriptif. Sasaran dalam penelitian ini adalah siswa MAN 2 Gresik dengan total 60 siswa. Hasil penelitian menunjukkan profil miskonsepsi siswa pada materi Substansi Genetika terdiri dari konsep RNA, DNA, kromosom, hubungan gen DNA dan kromosom, sintesis protein, dan replikasi DNA dengan persentase paham konsep sebesar 6,1%, 39,9% paham sebagian konsep, 41,8% siswa mengalami miskonsepsi, dan 12,2% tidak paham konsep. Faktor penyebab miskonsepsi terdiri dari siswa, buku ajar, media pembelajaran, dan cara mengajar. Penelitian lebih lanjut mengenai pengembangan media pembelajaran berbasis digital serta uji coba penerapan model dan metode pembelajaran pada materi substansi genetika perlu segera dilakukan untuk mereduksi miskonsepsi yang terjadi pada siswa.

Kata Kunci: *substansi genetika, miskonsepsi, four-tier diagnostic test*

INTRODUCTION

During teaching and learning activities, obstacles often arise and become a distraction when learning takes place. According to Piaget's view, knowledge is formed from the experiences of the students. Students will gain a new understanding through the process of constructing previously owned knowledge (Siregar & Harahap, 2010). The construction process can be obtained through interaction with the surrounding environment. Students will construct knowledge based on their experiences while learning with the learning environment. Therefore, mistakes are very likely to occur in the knowledge construction process in advance if the information sources are unclear and there is no assistance.

One of the obstacles that occur in the learning process is a misconception, inappropriate understanding of concepts. The type of misconception that each student fits in one can be different due to various causes. Therefore, teachers need to report student misconceptions and their causes. If misconceptions are not corrected immediately, they will continue and can affect the understanding of other concepts in the future.

The results of interviews with teachers and some students grade XII at MAN 2 Gresik showed that the Covid-19 pandemic also affected the teaching and learning process. Especially related to the limited learning model that can be used as well as the right methods when distance learning. Some students stated that genetic substance is one of the materials that is quite difficult to apply in Biology subjects, first during distance learning where students learn more independently.

Based on the results of research observations by Sarhim & Harahap (2015) in the City and District of Malang, 80% of the 7 teachers stated that genetics is difficult to teach. Of the 38 students, 75.8% also stated the same thing, while 3.4% stated that genetic material was classified as material that is very difficult to learn. The results of Treagust's (2011) study show the same thing that genetic material is considered difficult because it has a lot of difficult vocabulary and has abstract concepts for high school students. The difficulties in studying genetic material are caused by the fact that most genetic material is abstract and the lack of supporting learning media.

Genetic material, given to grade XII high school students, has many sub-materials with concepts that tend to be abstract. Concepts in genetics are considered problematic because they are discussed at the cellular and molecular levels. Students tend to have difficulty imagining images without being able to see them directly. Based on data from the Center for Educational Assessment of the Republic of Indonesia regarding mastery of the 2019 National Examination material in Gresik Regency, it was obtained that 57.68% of the high school / MA students are able to master the material of Genetics and Evolution (Pendidikan, 2019) . Researches related to the identification of misconceptions in genetics have also been widely carried out, Sari (2017) revealed that there were misconceptions in genetic substance with a percentage of 55.1% who did not understand the concept and 32.9% experienced misconceptions. A similar study was conducted by Elisa (2016) which revealed that there were misconceptions in the concept of DNA with a percentage of 58.6%. The two prior studies found misconceptions in the material of genetic substance. This research was conducted because it was found that there were many relevant studies showing misconceptions in genetic material. Besides that, considering the importance of genetic substance material which is also a prerequisite for studying the next material.

Identification of any misconceptions can be done with the help of diagnostic tests. Identification of student misconceptions can use multiple-choice tests, concept maps, and interviews (Kirbulut & Geban, 2014). A two-tier test is a form of a diagnostic test that consists of multiple-choice and reasons for choosing an answer in multiple-choice. Two-tier has a weakness, not being able to distinguish between mistakes due to lack of knowledge and errors due to misconceptions. Besides being unable to distinguish between correct answers based on guessing or not, this two-level multiple-choice test also causes the teacher to be unable to accurately determine how strong students are in understanding the concepts given (Rusilowati, 2015) . Then the test developed to overcome these limitations by including a confidence level as an additional level. Confidence level is used as the third level on the three-tier test. This diagnostic test consists of three stages, starting with multiple-choice, the reason for choosing the answer, and the level of confidence. According to Pesman & Eryilmaz (2010), the three-tier test is a combination of the two-tier test with the Certainty of Response Index (CRI) so that the percentage of misconceptions and being able to be between misconceptions and not understanding can be seen. Furthermore, the three-tier diagnostic test was developed into the four-tier diagnostic test. The development of this diagnostic test lies in the level of student confidence in choosing answers and reasons. Therefore, this method is considered as very appropriate to use to get accurate results.

Based on the description of the many misconceptions found in the Biology subject with genetic substance material and strengthened by data from the mastery of the concept of genetics and evolution material at the 2019 National Examination in Gresik district which is still low, it is necessary to have further research related to the misconceptions experienced by students in Gresik and their causes. Therefore, a study was compiled with the title "Profile of Misconception on Genetic Substance Topic on Student Grade XII with Four-Tier Diagnostic Test".

MATERIALS AND METHODS

The type of research chosen was a descriptive type of research with a quantitative approach. Quantitative descriptive research is a data collection activity that is then processed by statistical methods and then described so that it can describe the actual conditions. Before the diagnostic test research instrument was tested, validation was carried out by the material and education expert. Study items was measured using the Guttman scale, a score of 1 was given if it was following the aspect being assessed, if it was not fitted, it was assessed with a score of 0. The percentage of the feasibility of each item on the four-tier diagnostic test instrument can be calculated using the following formula:

$$\%\text{Eligibility} = \frac{\sum \text{appropriate answers from all reviewers}}{\sum \text{maximum number of answers from all reviewers}} \text{X } 100$$

The percentage value of eligibility was analyzed using the following validation score categories:

Table 1. Validation Score Categories (Jihad & Abdul, 2013)

Percentage (%)	Categories
≤ 25-38	Very invalid
39-52	Invalid
53-69	Quite valid
70-83	Valid
84-100	Very valid

After the question instrument was declared valid, then instrument testing was carried out. This research was conducted from October 2020 to January 2021. The target of this study was senior high school students of grade XII MIPA at MAN 2 Gresik with a total of 60 students. The results obtained from taking tests via *Google form* were then analyzed and matched with the categories of student conceptions based on the four-tier diagnostic test in Table 2.

Table 2.Categories of Students' Conception Grouping Based on Four-tier diagnostic test (Sandika, 2020)

Combination of answers				
Answers	**Confidence level of answers**	**Reason**	**Confidence level of reason**	**Categories**
T	S	T	S	**U**
T	S	T	N	
T	N	T	S	
T	N	T	N	
T	S	F	S	
T	S	F	N	
T	N	F	S	**PU**
T	N	F	N	
F	S	T	S	
F	S	T	N	
F	N	T	S	
F	N	T	N	
F	S	F	S	**M**
F	S	F	N	
F	N	F	S	**DU**
F	N	F	N	

Information: T = True, F = False, S = Sure, N = Not Sure, U = Understanding, PU = Partial Understanding, M = Misconception, DU = Do not Understand

Next, each category was processed into a percentage. To calculate the percentage, using the following formula:

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

Information:
P: Percentage of each group
f: The frequency that is being searched
N: The number of individuals

The misconceptions that occur in students were then grouped into three criteria, namely high misconceptions, moderate misconceptions, and low misconceptions as shown in the following table:

Table 3. Criteria for Classification of Misconceptions (Arikunto, 2010)

Criteria	Percentage
High	61% - 100%
Moderate	31% - 60%
Low	0% - 30%

Interviews were conducted with the Biology subject teacher and three students as a sample. The sources of the causes of misconceptions in students were grouped into four factors including students, books, teaching methods, and context. Meanwhile, the interview aspect for the teacher includes learning, concepts that are considered difficult, and misconceptions.

RESULTS AND DISCUSSION

The four-tier diagnostic test item instrument consisting of 20 items had gone through the validation process and the feasibility percentage was 89.4% or included in the very valid category. After being declared very valid, data was collected and the results of the student's misconception profile data on the genetic substance material were depicted in the following diagram:

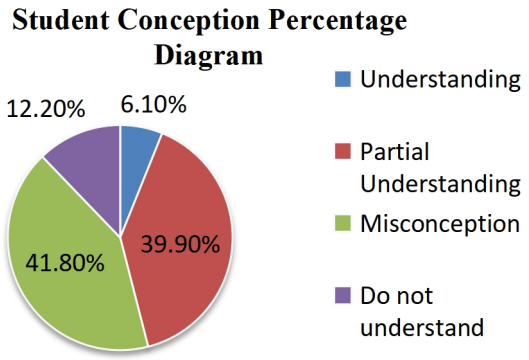

Figure 1. Student Conception Percentage Diagram

Based on figure 1, it shows that students who understand the concept of 6.1%, 39.9% understand some of the concepts, 41.8% of students experience misconceptions, and 12.2% do not understand the concept. The diagnostic test questions used consisted of nine concepts in the material of genetic substance. The following table shows the percentage of students' misconceptions on each concept:

Table 4. Percentage of Student Misconceptions on Each Concept in the Material of Genetic Substances

Concepts	Misconception (%)
RNA	61.7
DNA	38.1
Chromosome	32.2
DNA, Genes, and Chromosome Relationships	35.0
DNA Replication	58.3
Protein Synthesis	49.4

Based on the grouping of misconception criteria in Table 3, of the six concepts in the diagnostic test, five concepts were included in the medium misconception criteria and one concept included high misconception criteria. The five concepts included in the moderate misconception were the concepts of DNA, Chromosomes, DNA Linkage, Genes and Chromosomes, DNA Replication, and Protein Synthesis. The concept with the highest percentage of misconceptions lies in the concept of RNA, amounting to 61.7%.

The concept of RNA presented in the question was related to the role of various RNAs in protein synthesis. It is known that there are three main RNAs involved namely mRNA, tRNA, and rRNA. Students were still unable to determine the role of each RNA. Many students believe mRNA carries genetic information from the RNA in the nucleus to the ribosomes. The right answer regarding mRNA was located in the nucleus and cytoplasm. mRNA has the task of carrying information from DNA. Unlike the case with rRNA which is located in the cytoplasm and associated with ribosomes during the translation process. While tRNA has a function as binding to amino acids in the cytoplasm to be carried to ribosomes (Campbell, 2018).

DNA replication became a concept with the second-highest misconception rate percentage of 58.3%. Most students still do not understand the function of DNA replication. Most of the students think that the replication process is the same as the synthesis of proteins which can form mRNA and through the process of transcription and translation. The exact concept is related to replication, which is to form new, identical DNA before entering the cell division phase. The stages of replication are different from the protein synthesis process, which undergoes transcription first then translation. The replication stage starts from the initiation, elongation/polymerization, and termination stages (Yunita, 2016).

The third highest misconception occurs in the concept of protein synthesis. Students still do not understand the role of mRNA in the mechanism of protein synthesis. The majority of students answered that mRNA carries genetic information from RNA in the nucleus to ribosomes, it should be a true statement regarding mRNA, which is carrying genetic information from DNA in the cell nucleus to the ribosomes during the transcription process (Permata, 2018).

In another item that presented a protein synthesis diagram, students still misunderstood the translation stage by answering the part shown as the transcription stage. Besides, students also thought that transcription is a process of duplicating DNA. The correct concept is protein synthesis takes place in two stages, namely

transcription and translation. Transcription takes place in the cell nucleus, followed by translation, namely the translation of codons (mRNA) into amino acids in the cytoplasm, to be precise in the ribosomes. When it is in the transcription stage, DNA transcribed to mRNA and other types of RNA (Suhermiati, 2015) . Furthermore, translation occurs marked by tRNA adding an amino acid charge to the polypeptide chain when anti-codons form hydrogen bonds with complementary codons in mRNA so that codons can be translated into amino acids (Campbell, 2018).

The next concept that experienced misconception was DNA with a percentage of 38.1%. In this concept, there were several topics related to DNA, including the structure, function, and types of DNA. The items related to the subject of the structure and function of DNA presented a description of the statement and students believed that DNA can function in the forensic field through DNA analysis using amino acid sequences in certain molecules resulting from the translation of RNA / DNA. The correct answer is to use sequence analysis of a portion of the nucleus genomic DNA of the cell or mitochondrial DNA. The human genome contains many repeated DNA sequences, different for each individual, and varying in length and size so that it can be used for individual identification (Yudianto, 2020).

On the subject of DNA types, student misconception were also found. Some students stated that mitochondrial DNA was inherited from the father and has the same function as nuclear cell DNA. The correct concept is that mitochondrial DNA is inherited from the mother and has a major function in cellular respiration through enzymatic reactions (Hidayat, 2017).

The topic of DNA structure presented a problem related to one of the components of DNA, namely the nitrogen base. Students believed that the DNA sequence consists of nitrogenous bases adenine, uracil, guanine, and cytosine. The correct answer is related to the concept of the components that make up DNA, namely DNA is composed of four kinds of nitrogen bases which include adenine, thymine, guanine, and cytosine. Uracil is a component of the nitrogenous base building up RNA. In addition to nitrogenous bases, the DNA sequence is also composed of phosphate and pentose deoxyribose sugar (Dindar & Omer , 2011).

The relationship of DNA, Genes, and Chromosomes was also a concept that has a misconception. The problem presented in the diagnostic test was a picture of a nucleosome and students were asked to describe what a nucleosome is, some students believed that a nucleosome is a collection of twisted threads that contain genetic information. The correct statement regarding the nucleosome is the part of the histone protein association which looks like a bead and DNA which binds to each other along the DNA molecule (Wirth, 2007).

Another question addresses the basic components of nitrogen. Students were quite correct that adenine and guanine belong to the same nitrogen base group, but there were still those who answered that the two nitrogen bases were classified as pyrimidines. The correct concept regarding nitrogenous bases, there are two groups, namely purines and pyrimidines. There are four types of nitrogen bases in DNA, including adenine, guanine, thymine, and cytosine. Adenine and guanine are parts of purines, while thymine and cytosine are parts of pyrimidines (Rachmadiati, 2007)

The percentage of misconceptions on the concept of chromosomes could be said to be the concept with the lowest value compared to the other five concepts. However, this concept was still included in the criteria of moderate misconception. The concept of chromosomes discussed several topics including the structure, type, and shape of chromosomes. Students had not been able to distinguish the shape of the chromosomes from the images presented. Understanding the concept based on the students' answers was the most incorrect in determining the submetacentric form, it is considered to be metacentric. The correct answer refers to a picture showing a chromosome with the centromere located near the middle submedian called submetacentric. The metacentric chromosome shape has a relatively equal arm length and the centromere is right in the middle of the chromosome (Nusantari E. , 2013).

The subject of chromosome structure also experienced a misconception. Students were still wrong in determining genes and alleles based on the images presented. Some students believed alleles are pairs of genes that occupy different loci on homologous chromosomes. The right concept related to alleles is an alternative form/gene pair that occupies the same locus on the homologous chromosome or commonly written as gene A has allele a (Madukubah, 2018).

On the subject of chromosome types, some students still answered incorrectly regarding the concept of gonosomes and autosomes. Students believed that the gamete chromosome is the same as twice the somatic cell chromosome. The correct answer is gonosomes unpaired while autosomes are paired (Campbell, 2018).

From the results of the test to identify the level of student misconceptions, interviews were also conducted to investigate the factors causing the misconceptions in

students. The following table summarized the results of the interviews with the repondent in Table 5.

Table 5. Interview Results Related to Factors Causing Misconceptions

Factors of Misconception	Respondent Response
Student	The genetic substance is very abstract. Moreover, they have never studied face-to-face with the teacher about that material.
Books	Books are quite helpful in learning with written explanations of the material. Some pictures related to the material in the book are less clear.
Context	There are often differences in understanding, usually about nitrogenous bases and pictures related to chromosome structure and protein synthesis mechanisms.
Teacher	The teacher explains the material clearly and makes it easier for students to understand the material.
Teaching methods	The teacher uses PowerPoint slides as learning media and gives several examples of questions.

Based on the results of the interview in the table, it can be seen that the occurrence of misconceptions can come from students. Incomplete, simple, and different concept owned by students is one of the causes of misconceptions of student factors (Ibrahim, 2012) . Research conducted by Erman (2016) also shows that students' understanding is a factor in causing misconceptions. This is because students do not acquire complete knowledge and find it difficult to understand abstract and complex concepts. Kumandas (2015) research shows that meaningful learning will help reduce student confusion, therefore it can be linked between previous knowledge and new knowledge.

The main cause of misconceptions was also come from the learning resources used. During the interview, the teacher stated that the book given some differences in information such as the protein synthesis mechanism which has the potential to cause misconceptions. This is in line with the results of Nusantari's (2011) study which revealed that in high school book learning resources, misconceptions can be found in the concept of genetics. Misconceptions in textbooks are caused by the use of the wrong terms and language and inaccurate analogies.

Apart from these two factors, misconceptions may also occur due to factors of teaching methods. In the conditions of online learning during the Covid-19 pandemic era, teachers were also limited in choosing the use of learning models and methods. The learning method also determines the level of student understanding and assesses the extent to which students can absorb the material or concepts conveyed by the teacher (Mahendrawan, 2012).

Referring to several factors causing the misconceptions, alternative solutions to reduce the level of misconceptions that can be done are by using more interactive learning media, such as audio-visual. Audio-visual media will visualize more realistically like the real situation so that students understand more easily (Sudjana, 2010). The use of audio-visual teaching will be able to provide a stronger message (Nurani, 2016) . Murni (2016) also stated the same thing that the use of animated videos on protein replication and synthesis combined with blended learning has succeeded in helping to understand the concept of genetic substance.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the results of the study, it can be concluded that there is misconception of students on the material of genetic substance by 41.8%. The concept with the highest misconception is in the RNA concept with a percentage of 61.7%, while the lowest misconception is in the chromosome concept with a percentage of 32.2%. The factors causing the misconception come from the condition of students who are less interested in learning the material, the difference in information in textbooks as a learning resource, and the limited use of models, methods, and media used during the Covid-19 pandemic.

Recommendation

Further studies of the development and implementation of digital-based learning media on genetic substance material, especially on the concepts of RNA, DNA replication, and protein synthesis should be done near the future to reduce student misconceptions.

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