DETERMINANT FACTORS OF GENETIC MISCONCEPTION AT 12th GRADE SENIOR HIGH SCHOOL STUDENT IN SAMPANG

Faktor Determinan Miskonsepsi Genetika Pada Siswa Kelas XII SMA di Kabupaten Sampang

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Abstract

Twelfth grade senior high school students potentially have misconceptions in genetic material. The characteristics of genetic material are difficult to sense and complex, difficult to understand, and have the potential to cause misconceptions. Misconceptions can be caused by student factors, textbooks, contexts, teachers, and learning methods. This study aims to describe the categories of genetic misconceptions in students, to determine the determinant factors that cause the students' genetic misconceptions, and to give solutions in reducing or preventing the genetic misconceptions in students. The research used a mixed-method with sequential explanatory with multiple linear regression analysis on 58 samples of 12th-grade high school students in Sampang. The results of this study were categorization of students' genetic misconceptions percentage from low: moderate: high misconception, were 27.59%: 41.38%: 31.03%. Based on the high and medium categorization of students who have genetic misconceptions, 17.9% of the misconceptions were caused by student factors and learning methods. Student factor (X_1) has a significant positive effect on students' genetic misconceptions (Y) with the t value of 2.590. The contribution of students and learning methods to student misconceptions can be written with the equation Misconception = 51.285 + 0.268 Student - 0.256M.Learning. The solution to minimize students' genetic misconceptions is through clinical learning by conducting a misconception test and continued with the 5e learning cycle model learning such as engagement, exploration, explanation, elaboration, and evaluation. The implication of this study is teacher can strategize minimizing student factor in genetic misconception, such as through learning activity in the class.

Keyword: determinant factor, misconception, student's factor, learning method factor, 5e learning

Abstrak

Siswa SMA kelas XII berpotensi mengalami miskonsepsi pada materi genetika. Karakteristik materi genetika yang sulit diindera, kompleks, cenderung menyulitkan siswa memahami dan berpotensi menyebabkan miskonsepsi. Miskonsepsi dapat disebabkan oleh faktor siswa, buku teks, konteks, guru, dan metode pembelajaran. Penelitian ini bertujuan untuk mendeskripsikan kategori miskonsepsi genetika siswa, mendeterminasi faktor yang menentukan miskonsepsi genetika siswa serta memberikan solusi untuk mengurangi atau mencegah terjadinya miskonsepsi genetika pada siswa. Metode penelitian yang digunakan adalah mix method dengan sequential explanatory dengan analisis regresi linier berganda terhadap 58 sampel siswa SMA kelas XII di Kabupaten Sampang. Hasil penelitian ini adalah kategorisasi miskonsepsi genetika siswa berturut dari rendah : sedang : tinggi yaitu 27.59% : 41.38% : 31.03% . Berdasarkan kategorisasi tinggi dan sedang siswa yang mengalami miskonsepsi genetika, 17.9% miskonsepsi disebabkan karena faktor siswa dan metode pembelajaran. Faktor siswa (X_1) berpengaruh positif secara signifikan terhadap miskonsepsi genetika siswa (Y) dengan nilai t-hitung 2.590. Kontribusi siswa dan metode pembelajaran terhadap miskonsepsi siswa dapat dituliskan dengan persamaan Miskonsepsi = 51.285 + 0.268Siswa – 0.256M.Pembelajaran. Solusi meminimalkan miskonsepsi genetika siswa melalui pembelajaran klinis dengan melakukan uji miskonsepsi dan dilanjutkan dengan pembelajaran model 5e learning cycle meliputi fase engagement, exploration, explanation, elaboration, dan evaluation. Implikasi dari penelitian ini adalah guru dapat menyusun strategi untuk meminimalisir faktor siswa dalam miskonsepsi genetika contohnya melalui kegiatan pembelajaran di kelas.

Kata Kunci : *Faktor determinan, miskonsepsi, faktor siswa, faktor metode pembelajaran, 5e learning cycle.*

INTRODUCTION

National curriculum which is implemented in Indonesia have the purpose to foster Indonesian people to be productive, creative, innovative, and effective through an integrated attitude of skills and knowledge that is aligned with the skills of the 21st century. Learning activity in school plays an important role, especially in understanding basic concepts to bring out students who match the expectation of national curriculum. Mastering basic concepts are needed for the student to understand complex concepts and solve problems related to the concept that they study (Ardiyanti & Utami, 2017).

Conception in general definition is a person's interpretation of an object that is observed. Conception can be interpreted as the understanding of students in interpreting a certain concept (Ibrahim, 2019; Maharani et al., 2017; Wiyono et al., 2016). Students generally have a conception about a concept before they learn about that and it is not necessarily the same as the conception of experts, this is called preconception (Nurrahmawati & Prihandono, 2018; Pujianto, 2013). The inaccurate conception between what is understood by students and existing scientific concepts is called a misconception (Badruzzaman & Raharjo, 2019). Students can have misconceptions before or after learning in class. Resistant characteristic of misconception causes students who have misconceptions will have difficulties understanding concepts and continuously have that misconception (Permata & Ibrahim, 2018). Student with misconception in their mind can cause them to have the wrong application about the concept.

Misconceptions have negative impacts on students, especially in biology learning. The concepts in biology are interrelated, therefore students have to understand the basic concepts first before understanding and developing more complex concepts (Ardiyanti & Utami, 2017). Student misconception can cause the process of receiving and organizing new knowledge in the learning process to become obstructed (Saputri et al., 2016) even though the purpose of learning biology is to improve students' ability to understand, apply, and make connections between a biology concept to other biology concepts (Rahmawati, 2013).

Students potentially have misconceptions when learning concepts in biology, such as are genetic concepts. In addition to its character is diifficult to sense, the development of molecular genetics is not supported with the qualified textbook, instructional methods, experiment and only explains about genetic in classical perspective. That reason plays a role in causing students to have misconceptions (Etobro & Banjoko, 2017; Nusantari,

2011). Based on the research of Nusantari (2011), students have misconceptions about genetic material, especially about genetic substances. Education students in Selcuk Turkish University also have misconceptions about the genetic concept when they were given questions about the definition of gene. Respondents tend to give answers that point to classical genetics while the current development of science leads to molecular genetics (Dikmenli et al., 2011). Other reserach at preservice biology teachers in Lagos State University showed that they have the highest misconception in DNA sub-category (Etobro & Banjoko, 2017)

The causes of misconceptions can come from students' factors, textbooks, teachers, context, and learning methods (Kurniasih & Haka, 2017). Teachers who explain only the core of the concept and always use the lecture method in explaining a concept to students can causes misconceptions (Suhermiati et al., 2015). How teachers teaching in class is the cause of student misconceptions besides student own understanding (Kurniasih & Haka, 2017).

Students also have misconceptions because of interpreting their understanding based on textbooks and teacher explanations (Ardiyanti & Utami, 2017). Students' inaccurate preconceptions and lack of student's interest in learning are the main causes of students having misconceptions (Kurniasih & Haka, 2017).

The existence of misconceptions in students must be removed or reduced. Accordingly, the misconceptions will not be embedded in students. Teachers have an important role in determining the understanding of the concepts being learned by students. One of the solutions in reducing student misconception is a learning model that can be used to remediate student genetic misconceptions.

Based on the explanation above, the formulation of the problem in this study is "How are the determinants of genetic misconceptions from students and learning methods in Sampang?". The purpose of this study includes: (1) Describing the level of genetic misconceptions for 12th-grade high school students in Sampang (2) Determining the influence of students and learning methods to the genetic misconceptions of 12th-grade high school students in Sampang (3) Formulating solutions in remediation and prevent genetic misconceptions of 12th-grade high school students.

This research used a mixed-method with the sequential explanatory model which begins with a quantitative method using a misconception test and was continued by a qualitative method using student questionnaires. This research was conducted from August 2020 - January 2021.

The total sample used was 58 students consisting of 29 students of 12th public senior high school from SMAN 2 Sampang and 29 students of 12th private senior high school from SMA Sabilillah Sampang.

Data collection used an objective test method by adopting the Permata & Ibrahim research instrument (2018) with a modified certainty of response index (CRI) model test. The objective test was used to determine the percentage of student misconceptions. Student grouping based on concept understanding categories is presented in Table 1.

Table 1. Grouping of Respondents' Understanding Categories (Hakim et al., 2012)

Answer	Reason	Level of CRI	Description
True	True	>2.5	Understanding concepts
True	True	<2.5	Understanding concepts, lack of confidence
True	False	>2.5	Misconception
True	False	<2.5	Lack of knowledge
False	True	>2.5	Misconception
False	True	<2.5	Lack of knowledge
False	False	>2.5	Misconception
False	False	<2.5	Lack of knowledge

Students who have misconceptions were grouped based on the percentage of misconceptions. Student groupings are presented in Table 2.

Table 2. Categories of Student Misconceptions (Istighfarin et al., 2015)

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

Besides the objective test, this study also uses an observation method with a Guttman scale questionnaire as an instrument. Questionnaire questions were designed with a closed question model. The purpose of using this questionnaire was to determine the value of the factors caused by students and learning methods. Scores for the Guttman scale questionnaire are presented in Table 3.

Table 3. Score on the Guttman Scale (Sugiyono, 2012)

Response	Score
Yes	1
No	0

Due to Covid-19 Pandemic, data collection was carried out online via Google Form. The form of data in this study was the percentage of students' misconceptions on genetics material, questionnaire scores related to student and learning method as a cause of student misconceptions. Analysis of data using parametric statistics with multiple linear regression analysis techniques to determine the most influential factor of student misconception. The research variables used in this study are shown in Table 4:

Table 4. Research Variables

Variable	Explanation	Data Scale
Y	Student misconception	Ratio
X_1	Student's factor	Ratio
X_2	Learning methods factor	Ratio

The analysis steps included the classical assumption test as a condition of decision making in a regression model as good or not. There were three classical assumption tests in this study including the multicollinearity test, heteroscedasticity test, and normality test. If the form of data is time series, an autocolinearity test is required (Ghozali, 2016).

After testing the classical assumptions, it was continued to analyze the result of multiple linear regression tests to determine the relationship between the dependent variable and the independent variables. The general form of multiple regression can be written with:

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k + e \qquad (1)$$

Where

Y = dependent variable; X_1 and X_2 = independent variables; e = random residual / error / error; b_0 = intercept; b_1 and b_2 = partial regression coefficients

The multiple linear regression test consists of a simultaneous test which aims to determine the effect of all independent variables simultaneously on the dependent variable through the F-test). The coefficient of determination (R^2) in multiple linear regression is used to explain how much proportion of the variation in the dependent variable explained by all independent variables (Widarjono, 2015).

Partial test in this study has the purpose to determine independent variable effects to the dependent variable solely through the t-distribution test. The percentage of influence of each independent variable on the dependent variable can be determined based on the value of the effective contribution (SE) and the relative contribution (SR). SE and SR calculation refer to Hadi (2004). The entire data analysis process used SPSS 23.

RESULT AND DISCUSSION

The results of this study were the percentage of misconceptions, questionnaire scores on student factors and learning method factors, and the results of multiple linear regression analysis on the collected data. The categories of student misconceptions obtained from data collection are presented in the following figure:
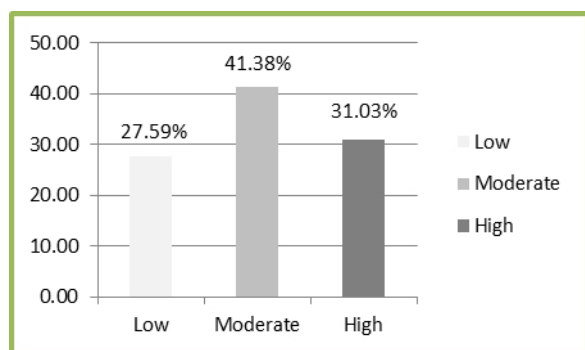

Figure 1. Categories of Student Misconceptions

Figure 1 showed that most of the students had misconceptions with the moderate category. The highest misconception was in the concept about differences of DNA and RNA. Students who had misconceptions on this concept had wrong understanding about the location of RNA and DNA. Students think that RNA is only found in nucleus while DNA can be found in nucleus and cytoplasm. The correct concept is RNA not only can be found in the nucleus but in cytoplasm too. RNA that can be found in the cytoplasm carries information from DNA (Hartwell et al., 2018). Based on these data, students with high and moderate misconception categories being analyzed with multiple linear regression.

Before doing multiple linier regression analysis, the data must be tested with a classical assumption as a condition of a good regression model. The multicollinearity test results based on the variance inflation factor (VIF) and tolerance values presented in Table 5.

Table 5. Multicolliniearity Test Result of Regression Model

Variable	Collinearity Statistics	
	Tolerance	VIF
X_1	0.952	1.050
X_2	0.952	1.050

Table 5 showed that the tolerance value of the two independent variables qualifies to > 0.10 and the VIF value <10. It can be concluded that the regression model free from multicollinearity which means this regression model has no correlation among the independent variables (Ghozali, 2016).

The heteroscedasticity test is also a condition for a good regression model. The results of the heteroscedasticity test can be analyzed based on the distribution of data on the scatterplot presented in Figure 2.
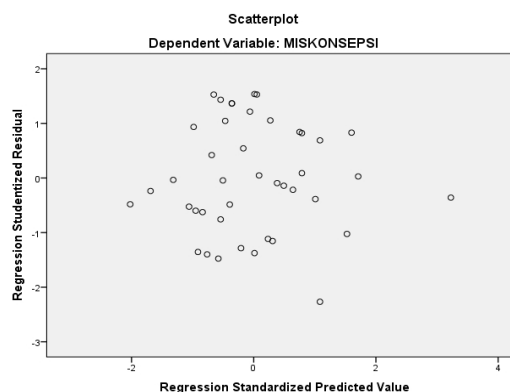

Figure 2. Scatterplot Test of Heteroscedasticity Regression Model

The results of the heteroscedasticity test showed that the distribution of data does not form a certain pattern and spreads above and below the number 0 on the Y-axis. It can be said that the regression model free from heteroscedasticity which means the residuals variance of one observation to another constant in this regression model (Ghozali, 2016). Besides, the residual normality test was also tested with the results presented in Figure 3
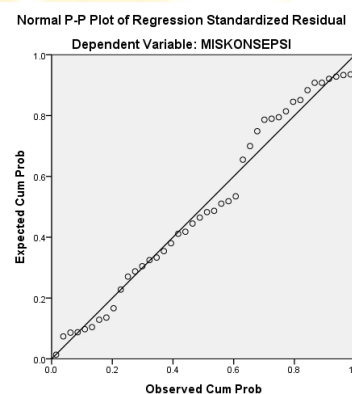

Figure 3. Histogram for Normality Test of Regression Model

The results of the normality test based on the histogram graph showed that the data spread around the diagonal line and follows the diagonal direction. Therefore the regression model can be said to qualify the assumption of normality (Ghozali, 2016). Besides using a histogram, normality assumption can be tested

statistically using the Kolmogorov-Smirnov test. Based on the results of the Kolmogorov-Smirnov test, the value of Asymp Sig. (2-tailed) was 0.2 which means the value was > 0.05. Therefore it can be said that the results of the Kolmogorov Smirnov regression model qualify the normality assumption (Ghozali, 2016), im accordance with the histogram interpretation in Figure 3.

Multiple linear regression analysis showed that in the simultaneous test (F-test). The significance value is 0.021 (< 0.05). The value of F is 4.251 with $\alpha = 0.05$ and F-table of 2.85, it can be said that F-value > F-table. Based on that significance value and the F value, H_0 was rejected, which means that the student factor (X_1) and the learning method factor (X_2) simultaneously affect the students' misconceptions (Y). Students and teachers have a role to play in the success of understanding concepts in students. If there is a misconception in students, it caused by the influence from the student factor and the learning methods carried out by the teacher because both are factors of the misconception (Ahmad & Indana, 2018; Suhermiati et al., 2015). The coefficient of determination in the multiple linear regression analysis of this study is presented in Table 8.

Table 6. Regression Model Determination Coefficient

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.423	0.179	0.137	12.64648

Based on the results in Table 6, the R Square value was 0.179, which means that 17.9% of student misconceptions can be explained by variations in student factors and learning method factors. Meanwhile, 82.1% was explained by other factors outside the model. The results of the analysis in Table 6 explain that external factors dominate as the causes of student genetic misconceptions. Other factors were possible to contribute as much as a percentage of 82.1%, including books or student learning resources, context, and teacher misconceptions (Kurniasih & Haka, 2017; Suhermiati et al., 2015). Based on research from Handoko & Sipahutar (2016), there two biology textbooks of 10th grade were found to have misconceptions with 20 misconceptions. Similar research was also carried out in 12th-grade biology textbooks. The results obtained that there was a misconception in the 12th-grade biology textbook with the largest percentage on growth and development, heredity, and metabolism materials with a percentage of 26.09% (Agustina et al., 2016). The life context of students such as mistakes in choosing discussion partners, language, culture, experience, and parental factors also play a role in causing students misconceptions (Fakhruddin et al.,

2012). Research on the pre-service teacher at Selcuk Turkish University reveals the fact that pre-service teachers have misconceptions about genetic material (Dikmenli et al., 2011). Misconceptions at teachers can cause errors in conveying genetic concepts to students (Nusantari, 2012).

The results of the partial test through the t-test distribution to determine the effect of each independent variable on the dependent variable indicate the significance value at X_1 is <0.05 with a t-value of 2.590 and t-table of 2.02439 ($t_{value} > t_{table}$). It can be said that the student factor (X_1) has a significant positive effect on student misconceptions (Y) which means increasing of student own factor can cause student misconceptions to increase. The test also showed that the learning method factor (X_2) has a significant value of 0.069 or > 0.05 with a value of t value -1.872 ($t_{value} < t_{table}$). It can be said that the learning method factor (X_2) does not significantly affect student misconceptions (Y). The effective contribution (SE) and the relative contribution of each independent variable are presented in Table 10.

Table 7. SE and SR Value of Independent Variables

Independent Variable	SE (%)	SR (%)
Student own factor (X_1)	12.5	70
Learning method (X_2)	5.4	30
Total	**17.9**	**100**

Table 7 showed that the value of the effective contribution and the relative contribution of student own factor variable was higher than the learning method variable, thus the student variables were more dominant in influencing or contributing to the occurrence of student misconceptions compared to the learning method factors. Kurniasih & Haka (2017) explained that the cause of students have misconceptions comes from the student's self with indicators such as preconception and a lack of student interest in learning. Lack of student interest in learning can reduce students' ability to understand concepts, therefore students have the potential to have misconceptions (Fadlan, 2011). The conception that students have before participating in learning and not necessarily the same as the expert's conception is called preconception (Pujianto, 2013). Inaccurate preconceptions stuck in the students' minds continuously even though learning has been given can cause misconceptions in students.

Besides, students have misconceptions because of associative thinking, humanistic thinking, incomplete reasoning, wrong intuition, cognitive development stages,

and student abilities (Fakhruddin et al., 2012; Halim et al., 2019). The differences in understanding that students have about the terms of concepts that are learned with the same terms in everyday life also contribute to misconceptions in students (Widiyatmoko & Shimizu, 2018). When students see all objects from a human perspective it causes students to have misconceptions. This is known as humanistic thinking (Fadllan, 2016). Students with cognitive development in the operational concrete stage have difficulty understanding abstract concepts, which can cause the concepts to be learned less or misunderstood (Fadlan, 2011). Althouh senior high school student in general is already past the concrete stage, there are some factors that influence cognitive development of students such as culture and students social life (Khiyarusoleh, 2016) Students often have incomplete or incorrect reasoning caused by the lack of information obtained by students. Intuition also plays a role in causing students to have misconceptions because students often use intuition or feelings to answer conceptual problems. Student's intuition is not necessarily based on objective and rational research results, therefore that intuition is wrong (Nurulwati et al., 2014).

The multiple linear regression model equation in this study was formulated as follows:

$$Misconception = 51.285 +$$
$$0.268\ Student -$$
$$0.256 Learning method$$

$$(2)$$

The equation above means that if the independent variable is constant, then the average percentage of student misconceptions is 51,285%. If each student's misconception score increases by 100, the misconception percentage will increase by 26.8%.

Regarding the problem of students' misconception, the researcher provided a solution in the form of clinical learning with genetic material using the 5e learning cycle model. The 5e learning cycle model was developed by Rodger W. Bybee and his colleagues. The learning cycle model is active learning for students based on Piaget's cognitive development theory and constructivism (Ulaş et al., 2012). This model can increase student interest in learning because students play an active role during the learning process. The 5e learning cycle model can reduce the proportion of student misconceptions from 46% to 2.8% (Taufiq, 2012). Learning with the 5e learning cycle model can also improve student achievement when compared to learning

that only uses lectures and concept maps (Ajaja, 2013; Ulaş et al., 2012).

The 5e learning cycle model has been widely used in teaching students about concepts. The syntax of the 5e learning cycle learning model includes engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006). The point of difference between the 5e learning cycle that is commonly used with the clinical learning developed by researchers is misconception test at the beginning of learning, therefore the teacher can find out the existence of student genetic misconception on the material to be studied. The clinical learning blueprint formulated by the researcher is depicted in Figure 4.
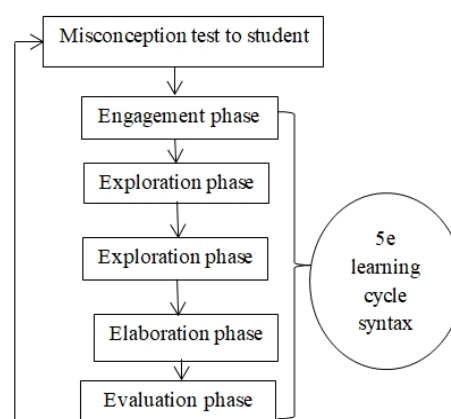

Figure 4. *Clinical Learning Blueprint 5e Learning Cycle Model.*

Student misconception tests at the beginning of learning are carried out to determine the existence of student misconceptions before getting learning material and minimize the presence of student preconception factors against student misconceptions (Kurniasih & Haka, 2017). Misconception tests can contain short questions with the CRI model, two-tier or other test models. The student misconceptions can be corrected through learning in the next phase.

The engagement phase aims to attract students attention, find out students' initial knowledge, and make a relationship between their knowledge and the material to be studied (Bybee et al., 2006). Through this engagement phase, the teacher can correct any preconceptions that students have about the material to be studied and students' misconceptions about the previous material.

The exploration phase is the phase where students explore knowledge and form their understanding of the concepts being learned (Bybee et al., 2006). Students can do a practicum or literature study at this phase to obtain information.

The explanation phase allows students to demonstrate an understanding of the concepts that have been obtained in the previous phase. Through this phase, the teacher provides in-depth reinforcement of concepts and checks for misconceptions that students got during the exploration phase (Bybee et al., 2006). Students can communicate their results through presentations or open and directed discussions in class forums.

The elaboration phase is the phase where students apply their knowledge related to concepts in new situations (Bybee et al., 2006). Teachers can provide study cases related to the concepts learned to students, therefore they can apply their understanding.

The evaluation phase is important in determining student's understanding of the material being studied (Bybee et al., 2006). The test given to students at the end of the lesson can be used to determine student learning outcomes. Teacher can also ask students to create a portfolio about the material studied to assess scientific literacy skills. Portfolio can be created in electronic portfolio form if possible. Through electronic portfolio, teacher can assess students scientific skills easier (Prastiwi et al., 2020)

CLOSING
Conclusion
Based on this research, the conclusions can be obtained. First, the categorization of students' genetic misconceptions in a row from low : medium : high is 27.59% : 41.38% : 31.03%. Second, based on the category of moderate and high misconceptions of students, 17.9% of genetic misconceptions are influenced by student factors and learning method factors, while 82.1% are influenced by factors outside the regression model. Third, the student factors (X_1) significantly had a positive effect on students' misconceptions with a t-value value is 2.590. Fourth, contribution of student factors and learning methods to genetic misconceptions can be written with the equation Misconception = 51.285 + 0.268 Student - 0.256M. Learning. Fifth, solutions that can be used to minimize genetic misconceptions are to give clinical learning with a misconception test and continue with the 5e learning cycle model learning to students.

Suggestion
Other studies related to the determinant factors of student genetic misconceptions are needed to determine the effect of other factors except students and learning. Also, further research related to clinical learning in genetic learning material with a learning cycle model is needed to see its

theoretical and empirical validity and its effectiveness in reducing and preventing genetic misconceptions.

REFERENCES

Agustina, R., Sipahutar, H., & Harahap, F. (2016). Analisis Miskonsepsi Pada Buku Ajar Biologi SMA Kelas XII. *Jurnal Pendidikan Biologi*, *5*(2), 87–95.

Ahmad, M., & Indana, S. (2018). Pengembangan Instrumen Tes Miskonsepsi Siswa Menggunakan Kombinasi Three-Tier Test Dan Certainty Of Response Index. *BioEdu*, *7*(2), 119–128.

Ajaja, O. P. (2013). *Which strategy best suits biology teaching. 17*(1), 20–21.

Ardiyanti, Y. &, & Utami, M. R. (2017). Identifikasi Miskonsepsi Siswa Pada Materi Sistem Reproduksi. *Biosfer, J. Bio. & Pend. Bio.*, *2*(2), 18–23. https://doi.org/ISSN: 2549-0486

Badruzzaman, A., & Raharjo. (2019). Profil Miskonsepsi Siswa Pada Materi Sistem Endokrin. *BioEdu*, *8*(2), 225–231.

Bybee, R. W., Taylor, J. A., Gardner, A., Scotter, P. Van, Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E Instrutional Models : Origins and Effectiveness*.

Dikmenli, M., Cardak, O., & Kiray, S. A. (2011). Science Student Teachers' Ideas about the "Gene" Concept. *Procedia Social and Behavioral Sciences*, *15*, 2609–2613. https://doi.org/10.1016/j.sbspro.2011.04.155

Etobro, A. B., & Banjoko, S. O. (2017). *Misconceptions of Genetics Concept Among Pre-Service Teachers*. *16*, 121–128. https://doi.org/http://dx.doi.org/10.4314/gjedr.v16i2.6

Fadlan, A. (2011). Model Pembelajaran Konflik Kognitif Untuk Mengatasi Miskonsepsi Pada Mahasiswa Tadris Fisika Program Kualifikasi S.1 Guru Madrasah. *Phenomenon : Jurnal Pendidikan MIPA*, *2*(1), 139–159.

Fadllan, A. (2016). Model Pembelajaran Konflik Kognitif Untuk Mengatasi Miskonsepsi Pada Mahasiswa Tadris Fisika Program Kualifikasi S.1 Guru Madrasah. *Phenomenon : Jurnal Pendidikan MIPA*. https://doi.org/10.21580/phen.2011.1.2.441

Fakhruddin, Azizahwati, & Rahmi, Y. (2012). Analisis Penyebab Miskonsepsi Siswa pada Pelajaran Fisika di Kelas XII SMA / MA Kota Duri. *Jurnal Pendidikan Matematika*, *3*(1), 87–98.

Ghozali, I. (2016). *Aplikasi Analisis Multivariete dengan Program IBM SPSS 23* (8th ed.). Badan Penerbit Universitas Diponegoro.

Hadi, S. (2004). *Analisis Regresi*. Andi.

Hakim, A., Liliasari, & Kadarohman, A. (2012). Student Concept Understanding of Natural Products Chemistry in Primary and Secondary Metabolites Using the Data Collecting Technique of Modified CRI. *International Online Journal of Educational Sciences*.

Halim, A., Lestari, D., & Mustafa. (2019). Identification of the causes of misconception on the concept of dynamic electricity Identification of the causes of misconception on the concept of dynamic electricity. *Journal of Physics : Conference Series*, *1280*(052060). https://doi.org/10.1088/1742-6596/1280/5/052060

Handoko, R., & Sipahutar, H. (2016). Analisis Miskonsepsi Pada Buku Teks Biologi Sma Kelas X Berbasis Kurikulum Tingkat Satuan Pendidikan 2006 Dan Kurikulum 2013 Di Kota Tebing Tinggi. *Jurnal Pelita Pendidikan*, *4*(1), 39–47.

Hartwell, L. H., Goldberg, M. L., Fischer, J. A., & Hood, L. (2018). *Genetics : From Genes to Genomes* (Sixth). McGraw-Hill Education,.

Ibrahim, M. (2019). *Model Pembelajaran P2OC2R Untuk Mengubah Konsepsi IPA Siswa*. Zifatama Jawara.

Istighfarin, L., Rachmadiarti, F., & Budiono, J. D. (2015). Profil Miskonsepsi Siswa Pada Materi Struktur dan Fungsi Jaringan Tumbuhan. *BioEdu*, *4*(3), 991–995.

Khiyarusoleh, U. (2016). Konsep Dasar Perkembangan Kognitif pada Anak Menurut Jean Piaget. *Dialektika*, *5*(1), 1–10.

Kurniasih, N., & Haka, N. B. (2017). Penggunaan Tes Diagnostik Two-Tier Multiple Choice Untuk Menganalisis Miskonsepsi Siswa Kelas X Pada Materi Archaebacteria Dan Eubacteria. *Biosfer: Jurnal Tadris Biologi*, *8*(1), 114–127. https://doi.org/10.24042/biosf.v8i1.1270

Maharani, H. R., Ubaidah, N., & Aminudin, M. (2017). Konsepsi Awal Siswa SMP Tentang Kubus. *JPM : Jurnal Pendidikan Matematika*, *3*(2), 22. https://doi.org/10.33474/jpm.v3i2.621

Nurrahmawati, Y., & Prihandono, T. (2018). Prakonsepsi Siswa SMK Tentang Rangkaian Listrik Sederhana dalam Pembelajaran Fisika. *Prosiding Seminar Nasional Pendidikan Fisika 2018 "Implementasi Pendidikan Karakter Dan IPTEK Untuk Generasi Millenial Indonesia Dalm Menuju SDGs 2030,"* 241–246.

Nurulwati, Veloo, A., & Ali, R. M. (2014). Suatu Tinjauan Jenis-Jenis dan Penyebab Miskonsepsi Fisika. *Jurnal Pendidikan Sains Indonesia*, *2*(1), 87–95.

Nusantari, E. (2011). Analisis dan Penyebab Miskonsepsi pada Materi Genetika Buku SMA Kelas XII. *Jurnal Bioedukasi*. https://doi.org/10.7821/jppundiksha.v43i1.1701

Nusantari, E. (2012). Perbedaan Pemahaman Awal Tentang Konsep Genetika Pada Siswa, Mahasiswa, Guru dan Dosen. *Jurnal Ilmu Pendidikan*, *18*(2), 244–252.

Permata, S. I., & Ibrahim, M. (2018). Profil Miskonsepsi Siswa SMA pada Materi Sintesis Protein Menggunakan Three-Tier Test. *BioEdu*, *7*(3), 490–495.

Prastiwi, M. S., Yogyakarta, U. N., Surabaya, U. N., Kartowagiran, B., Yogyakarta, U. N., Susantini, E., & Surabaya, U. N. (2020). Assessing Using Technology : Is Electronic Portfolio Effective To Assess the Scientific Literacy on Evolution Theory. *IJET*, *15*(12), 230–243. https://doi.org/https://doi.org/10.3991/ijet.v15i12.12227

Pujianto, A. (2013). Analisis Konsepsi Siswa Pada Konsep Kinematika Gerak Lurus. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*. https://doi.org/10.22487/j25805924.2013.v1.i1.2370

Rahmawati, Y. (2013). Studi Komparasi Tingkat Miskonsepsi Siswa Pada Pembelajaran Biologi Melalui Model Pembelajaran Konstruktivisme Tipe Novick Dan Konstruktivis-Kolaboratif. *Jurnal Pendidikan Biologi*, *7*, 11–26.

Saputri, L. A., Muldayanti, N. D., & Setiadi, A. E. (2016). Analisis Miskonsepsi Siswa Dengan Certainty Of Response Index (CRI) Pada Submateri Sistem Saraf Di Kelas XI IPA SMA Negeri 1 Selimbau. *Jurnal Bioeducation*, *3*(2). https://doi.org/10.29406/186

Sugiyono. (2012). *Metode Penelitian Kuantitatif Kualitatif dan R&D*. Alfabeta.

Suhermiati, I., Sifak, I., & Rahayu, Y. S. (2015). Analisis Miskonsepsi Siswa Pada Materi Pokok Sintesis Protein Ditinjau Dari Hasil Belajar Biologi Siswa. *BioEdu*, *4*(3), 985. http://jurnalmahasiswa.unesa.ac.id/index.php/bioedu/article/view/13429/12328

Taufiq, M. (2012). Remediasi miskonsepsi mahasiswa calon guru fisika pada konsep gaya melalui penerapan model siklus belajar (Learning cycle)

5E. *Jurnal Pendidikan IPA Indonesia*, *1*(2), 198–203. https://doi.org/10.15294/jpii.v1i2.2139

Ulaş, A. H., Sevim, O., & Tan, E. (2012). *Social and The effect of worksheets based upon 5e learning cycle model on student success in teaching of adjectives as grammatical components*. *00*(2011), 391–398. https://doi.org/10.1016/j.sbspro.2011.12.072

Widarjono, A. (2015). *Statistika Terapan Dengan Excel & SPSS* (Pertama). UPP STIM YKPN.

Widiyatmoko, A., & Shimizu, K. (2018). Literature Review of Factors contributing to Students' Misconceptions in Light and Optical Instruments. *International Journal of Environmental & Science Education*, *13*(10), 853–863.

Wiyono, F. M., Sugiyanto, S., & Yulianti, E. (2016). Identifikasi Hasil Analisis Miskonsepsi Gerak Menggunakan Instrumen Diagnostik Three Tier Pada Siswa SMP. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*. https://doi.org/10.26740/jpfa.v6n2.p61-69