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Critical thinking, metacognitive skills, and cognitive learning outcomes: A correlation study in genetic

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ABSTRACT

Understanding the concept of genetics needs to be balanced with high-level thinking and excellent metacognitive skills. However, efforts to measure the correlation between these two factors are still carried out partially. This study aims to determine the correlation between critical thinking, metacognitive skills, and cognitive learning outcomes in genetic. This study is correlational that measures the relationship between variables of students' critical thinking skills (X1), metacognitive skills (X2), and students' cognitive learning outcomes (Y). As much as 118 students who took the genetic course were involved as the population as well as research subjects. Data collection instruments in this study consisted of tests of critical thinking skills and metacognitive skills tests as well as students' cognitive assessment sheets. The results showed that the achievement of student cognitive learning outcomes was influenced by 94% of the dependent variables examined in this study, while other variables influenced the remaining 6%. The conclusion of this study recommends that the regression models and coefficients used in this regression can be used to predict cognitive learning outcomes.

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INTRODUCTION

Genetics is an essential subject that needs to be mastered to understand the context and biological problems (Murray-Nseula, 2011; Wahyono, Hindun, Muizzudin, & Miharja, 2016). Various phenomena related to life can be explained by concepts and genetic studies (Al khawaldeh, 2013; Fauzi & Ramadani, 2017). Genetic studies are widely used as a basis for the development of research with molecular and biotechnological approaches (Pearson & Hughes, 1986a, 1986b). Thus, understanding the concepts of right and comprehensive genetics is essential for students (Nyamupangedengu & Lelliott, 2018).

However, various previous studies has shown the opposite. Students tend to face difficulties because they do not have a good understanding of concepts (Nusantari, 2012). Fauzi and Fariantika (2018) report that genetics, including subjects that are classified as difficult to understand. In line with the results of the research reported by Murray-Nseula (2011), Mustika, Hala, and Arsal (2014) which states that many students experience difficulties because of the characteristics of genetic concepts that tend to be complicated and abstract. Some of the strong reasons that arise on the question of why genetics is difficult to understand are the abtract trait of genetics (Topçu & Şahin-Pekmez, 2009). Genetic discussion topics such as gametes and chromosomes (Murray-Nseula, 2011) also genes and DNA (Duncan & Reiser, 2007) are substances that require molecular-microscopic observation to study them. With these unique characteristics, studying genetics involves an understanding of tiered and interrelated concepts (Kiliç & Sağlam, 2014).

Genetic learning in higher education needs to be designed and developed by accommodating the uniqueness of the concepts learned (Carlson & Marshall, 2009; Murray-Nseula, 2011; Nyamupangedengu & Lelliott, 2018). Development carried out needs to consider material characteristics (Al khawaldeh, 2013; Topçu & Şahin-Pekmez, 2009), indicator (Prayogi, Yuanita, & Wasis, 2017), goals (Freidenreich, Duncan, & Shea, 2011), and selection of appropriate learning models (Yilmaz, Tekkaya, & Sungur, 2011). Several studies have been conducted to improve genetic lectures, among others, by restructuring concepts (Orcajo & Aznar, 2005; Pearson & Hughes, 1986b) implementing of collaborative learning and lesson study (Wahyono et al., 2016), and developing teaching material (Ardiansyah, Corebima, & Rohman, 2017).

Also, teachers need to identify factors correlate with students' conceptual understanding (Orcajo & Aznar, 2005). Metacognitive (Dwyer, Hogan, & Stewart, 2014) and critical thinking skills (Arslan, 2015; Choy & Cheah, 2009; Leach, 2011) are indicated to be closely related to learning achievement and conceptual understanding. Metacognitive is needed to sort, choose, analyze, and internalize the concepts that have been owned (Jagals & Walt, 2016; Panchu, Bahuleyan, Seethalakshmi, & Thomas, 2016). On the other hand, critical thinking skills in genetic learning are closely related to the ability to identify, understand, and draw conclusions on certain phenomena (Naimnule & Corebima, 2018; Reece, 2005).

The study of critical thinking skills, metacognitive skills, and their impact on learning outcomes has been done previously (Arslan, 2015; Bensley & Spero, 2014; Ramdiah, Abidinsyah, Royani, & Husamah, 2019). These studies took subjects in secondary schools, among others, in junior secondary schools (Akyol, Sungur, & Tekkaya, 2010; Liu, He, & Li, 2015) and senior high schools (Naimnule & Corebima, 2018; Tzohar-Rozen & Kramarski, 2014). However, no studies has examined the two possible correlations with the results of studying genetics in universities. Whereas, information regarding critical thinking skills, metacognitive skills, and cognitive learning outcomes is essential to be mapped to analyze the achievements of genetic learning and make further improvements. Therefore, this study aimed to determine the correlation between critical thinking, metacognitive skills, and cognitive learning outcomes in genetic studies.

METHODS

Design of the Study

This study was correlational survey to find out the relationship between two independent variables on the dependent variable (Figure 1). The independent variables in this study are critical thinking skills (X_1) and metacognitive skills (X_2), while the dependent variable is student cognitive learning outcomes (Y). The study was conducted for one semester in the 2017/2018 school year.

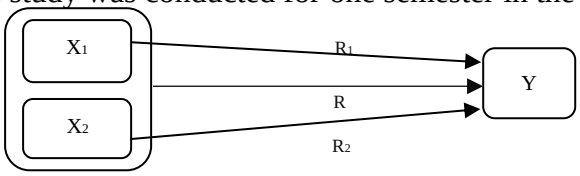

Figure 1. Correlational research design

Participant

The entire student population in this study was involved as a subject. The population of this study was 118 students of the fourth semester Department of Biology Education, Universitas Muhammadiyah Malang (UMM), who were taking Genetics lectures in the odd semester of 2017-2018 consisting of 98 women and 20 men. In more detail, 118 students consisting of 39, 40, and 39, were divided into three classes in sequence.

Procedure

In this study, all research subjects followed the Genetics lectures for half semester. During the study, Genetics lectures were set up as natural Genetics course activities, which are usually held at UMM (presentations and discussions activities). After that, data retrieval was conducted using test instruments that have been prepared. The allocation of test time was 60 minutes and carried out simultaneously in all three classes.

Instrument

There were three types of data taken in this study, and all of these data were collected through a test instrument. The test instrument consisted of five open-ended question items. Furthermore, using the rubric developed by Zubaidah, Corebima, & Mistianah (2015) and Corebima (2009), data on critical thinking skills and metacognitive skills were collected consecutively. On the other hand, cognitive learning outcomes data were collected by scoring students' answers through a Likert scale. Likert scale used consists of three scales, i.e., 1 = wrong answer (both answers and reasons are wrong), 2 = almost correct (only the answer is correct, the reason is wrong), and 3 = correct answer (both answers and reasons are correct).

Data Analysis

The collected data were analyzed using Pearson Correlation and multiple linear regression analysis. Pearson correlation was used to determine whether there is a correlation between each predictor (critical thinking and metacognitive skills) on criterium (learning outcomes) or not. Meanwhile, multiple linear regression was used to predict learning outcomes achievement of predictor variables. The significance level used in the analysis was 5%.

RESULTS AND DISCUSSION

The analysis results show that both of the predictor variables (critical thinking skills and metacognitive skills) has a significant correlation with cognitive learning outcome (Table 1). Variables of critical thinking skills have a correlation of 96% on the acquisition of cognitive learning outcomes, while metacognitive skills influence the achievement of learning outcomes by 66%.

Table 1.
The correlation test parameters for critical thinking and metacognitive skills with cognitive learning outcomes

Predictors	Pearson Correlation	Sig. (1-tailed)
Critical thinking skills	.968	<.05
Metacognitive skills	.663	<.05

The combination of the two variables shows a strong correlation with learning outcomes. Simultaneously, critical thinking skills and metacognitive skills had an effect of 94% on student cognitive learning outcomes. These indicate that only 6% of student learning outcomes are affected by other factors out of the two variables. The correlation between the two variables is explained in Table 2.

Table 2.
Prediction of the correlation between the two independent variables on learning outcomes

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.969[a]	.940	.938	2.83478

The combination of the two variables on the learning outcomes shows the significance of the regression equation F = 893,083 with significance < 0.05 (Table 3). These indicate that the regression models of the two independent variables can be used to predict the achievement of cognitive learning outcomes.

Table 3.
The independent variable regression model of learning outcomes

Model		Sum of Squares	df	Mean Square	F	Sig
1	Regression	14353.627	2	7176.813	893.083	<.05
	Residual	924.140	115	8.036		
	Total	15277.767	117			

The regression model can be used to create a regression equation that describes the relationship of the two independent variables to the dependent variable (Table 4) These results indicate that the equation $Y = -5.019 + 1.110X_1 - 0.087X_2$ can predict the dependent variable.

Table 4.
The independent variable regression coefficient model of learning outcomes

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.019	.846		-5.933	<.05
	Critical thinking skills	1.110	.036	1.020	30.810	<.05
	Metacognitive skills	-.087	.040	-.073	-2.195	<.05

The correlation of critical thinking skills and partial metacognitive skills to the success of cognitive learning reinforces the results of previous studies (Choy & Cheah, 2009; Jagals & Walt, 2016; Kono & Mamu, 2016; Liu et al., 2015; Tamsyani, 2016). The results of this study indicate that critical thinking skills and metacognitive skills have a significant role in predicting achievement of cognitive learning (Arslan, 2015), especially in understanding the concept of genetics (Kiliç & Sağlam, 2014). Optimizing high-level thinking skills is seen as an effective way to understand a genetic phenomenon (Murray-Nseula, 2011). By activating critical thinking skills, students can see broader in analyzing a phenomenon. These will have an impact on mental, social, and even spiritual maturity so that students become more mature in their efforts to understand the concept (Zubaidah et al., 2015).

Besides, strengthening students' critical thinking skills is essential in the 21st Century learning in higher education (Stupple et al., 2017) and the development of genetic science (Stern & Kampourakis, 2017). These are followed by the increasing number of recent discoveries that require students to associate these findings with existing concepts and understandings (Kiliç & Sağlam, 2014; Orcajo & Aznar, 2005). Herein lies the challenge, so that the urgency of optimizing students' critical thinking skills is at a level that deserves attention (Murray-Nseula, 2011). Students need to be accustomed with high-level thinking to map problems, provide analysis from a variety of different perspectives, provide solutions, and set them (Dwyer et al., 2014; Scott, 2015).

The results of this study also illustrate that simultaneously critical thinking and metacognitive skills are factors that can predict cognitive learning outcomes. The combination of these two skills becomes a fundamental and complex strategy used to process information input (Akyol et al., 2010; Jagals & Walt, 2016; Miri, David, & Uri, 2007). The combination of both has been implemented in various intellectual activities including elaboration, organizing, and regulating concepts that have slices with genetics such as molecular biology (Carlson & Marshall, 2009), biochemistry (Pearson & Hughes, 1986a), ecology (Duncan & Reiser, 2007), even evolution (Orcajo & Aznar, 2005; Yilmaz et al., 2011).

However, although both have a strong correlation with the success of cognitive learning, constructive efforts are needed to help students improve critical thinking skills and metacognitive skills (Duncan & Reiser, 2007; Kiliç & Sağlam, 2014). According to some relevant literature, both are influenced by various internal and external students' factors (Naimnule & Corebima, 2018; Stupple et al., 2017; Tzohar-Rozen & Kramarski, 2014). Internal factors in question include knowledge already owned (Al khawaldeh, 2013; Tsui & Treagust, 2005) and gender (Nyamupangedengu & Lelliott, 2018), while external factors include appropriate learning media (Stern & Kampourakis, 2017) and the way teachers teach (Al khawaldeh, 2013; Topçu & Şahin-Pekmez, 2009).

These factors, in the implementation of learning, need to be considered to optimize the empowerment of critical thinking and student metacognitive. The results of this study can be used as a basic strategy for conducting lecture development (Amin & Adiansyah, 2018; Bensley & Spero, 2014). Teachers can develop genetic lectures by innovating such as the use of collaborative learning models (Guleker, 2015), learning strategies that facilitate the development of thinking skills (Ghanizadeh, 2017), and the use of media and learning resources that are relevant to student characteristics (Duncan & Reiser, 2007; Murray-Nseula, 2011).

CONCLUSION

The results showed that the regression model and the coefficients in this study could be used as predictors in line with critical thinking skills and metacognitive skills, which simultaneously positively correlate with cognitive learning outcomes. These results need to be interpreted by carrying out various innovative and integrative efforts in the learning process, so that differences in internal and external factors that affect both can be used as a basis for efforts to empower critical thinking skills and students' metacognitive skills.

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REFERENCES

Akyol, G., Sungur, S., & Tekkaya, C. (2010). The contribution of cognitive and metacognitive strategy use to students' science achievement. *Educational Research and Evaluation*, *16*(1), 1–21. Doi: https://doi.org/10.1080/13803611003672348

Al khawaldeh, S. A. (2013). Prediction/discussion-based learning cycle versus conceptual change text: Comparative effects on students' understanding of genetics. *Research in Science and Technological Education*, *31*(2), 168–183. https://doi.org/10.1080/02635143.2013.811576

Amin, A. M., & Adiansyah, R. (2018). Lecturers ' perception on students ' critical thinking skills development and problems faced by students in developing their critical thinking skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(1), 1–10. Doi: https://doi.org/10.22219/jpbi.v4i1.5181

Ardiansyah, R., Corebima, A. D., & Rohman, F. (2017). Pengembangan bahan ajar mutasi genetik pada matakuliah genetika. *Jurnal Pendidikan: Teori, Penelitian Dan Pengembangan*, *2*(7), 927–933. Doi: https://doi.org/10.17977/jptpp.v2i7.9646

Arslan, S. (2015). Investigating predictive role of critical thinking on metacognition with structural equation modeling. *The Malaysian Online Journal of Educational Science*, *3*(2), 1–10. https://mojes.um.edu.my

Bensley, D. A., & Spero, R. A. (2014). Improving critical thinking skills and metacognitive monitoring through direct infusion. *Thinking Skills and Creativity*, *12*, 55–68. https://doi.org/10.1016/j.tsc.2014.02.001

Carlson, D. L., & Marshall, P. A. (2009). Learning the science of research, learning the art of teaching: Planning backwards in a college genetics course. *Bioscience Education*, *13*(1), 1–9. Doi: https://doi.org/10.3108/beej.13.4

Choy, S. C., & Cheah, P. K. (2009). Teacher perceptions of critical thinking among students and its influence on higher education. *International Journal of Teaching and Learning in Higher Education*, *20*(2), 198–206. Retrieved from https://eric.ed.gov

Corebima, A. D. (2009). Metacognitive skill measurement integrated in achievement test. In *Third International Conference on Science and Mathematics Education(CoSMEd)*. Penang: SEAMEO Regional Centre for Education in Science and Mathematics. Retrieved from http://ftp.recsam.edu.my/cosmed/cosmed09/AbstractsFullPapers2009/Abstract/Science Parallel PDF/Full Paper/01.pdf

Duncan, R. G., & Reiser, B. J. (2007). Reasoning across ontologically distinct levels: Students' understandings of molecular genetics. *Journal of Research in Science Teaching*, *44*(7), 938–959. Doi: https://doi.org/10.1002/tea.20186

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st century. *Thinking Skills and Creativity*, *12*, 43–52. Doi: https://doi.org/10.1016/j.tsc.2013.12.004

Fauzi, A., & Fariantika, A. (2018). Courses perceived difficult by undergraduate students majoring in biology. *Biosfer: Jurnal Pendidikan Biologi*, *11*(2), 78–89. Doi: https://doi.org/10.21009/biosferjpb.v11n2.78-89

Fauzi, A., & Ramadani, S. D. (2017). Learning the genetics concepts through project activities using Drosophila melanogaster: A qualitative descriptive study. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *3*(3), 238–247. Doi: https://doi.org/10.22219/jpbi.v3i3.4540

Freidenreich, H. B., Duncan, R. G., & Shea, N. (2011). Exploring Middle School Students' Understanding of Three Conceptual Models in Genetics. *International Journal of Science*

Education, *33*(17), 2323–2349. Doi: https://doi.org/10.1080/09500693.2010.536997

Ghanizadeh, A. (2017). The interplay between reflective thinking, critical thinking, self-monitoring, and academic achievement in higher education. *Higher Education*, *74*(1), 101–114. Doi: https://doi.org/10.1007/s10734-016-0031-y

Guleker, R. (2015). Instructional strategies to foster critical thinking: Self-reported practices of the faculty in Albania. *International Journal of Teaching and Education*, *III*(4), 6–14. Doi: https://doi.org/10.20472/TE.2015.3.4.002

Jagals, D., & Walt, M. Van Der. (2016). Enabling metacognitive skills for mathematics problem solving: a collective case study of metacognitive reflection and awareness. *African Journal of Research in Mathematics, Science and Technology Education*, *20*(2), 154–164. Doi: https://doi.org/10.1080/18117295.2016.1192239

Kiliç, D., & Sağlam, N. (2014). Students understanding of genetics concepts: The effect of reasoning ability and learning approaches. *Journal of Biological Education*, *48*(2), 63–70. Doi: https://doi.org/10.1080/00219266.2013.837402

Kono, R., & Mamu, H. D. (2016). Pengaruh model problem-based learning (pbl) terhadap pemahaman konsep biologi dan keterampilan berpikir kritis siswa tentang ekosistem dan lingkungan di kelas x sma negeri 1 sigi. *Jurnal Sains Dan Teknologi Tadulako*, *5*(4), 28–38. Retrieved from http://jurnal.untad.ac.id

Leach, B. T. (2011). *Critical thinking skills as related to university students' gender*. East Tennessee State University. Retrieved from https://dc.etsu.edu

Liu, Z. K., He, J., & Li, B. (2015). Critical and creative thinking as learning processes at top-ranking Chinese middle schools: possibilities and required improvements. *High Ability Studies*, *26*(1), 139–152. Doi: https://doi.org/10.1080/13598139.2015.1015501

Miri, B., David, B., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in Science Education*, *37*, 353–369. Doi: https://doi.org/10.1007/s11165-006-9029-2

Murray-Nseula, M. (2011). Incorporating case studies into an undergraduate genetics course. *Journal of the Scholarship of Teaching and Learning*, *11*(3), 75–85. Retrieved from https://scholarworks.iu.edu

Mustika, A. A., Hala, Y., & Arsal, A. F. (2014). Identification of misconception of biology students at state university of makassar on genetic concept by applying cri method. *Jurnal Sainsmat*, *III*(2), 122–129. Retrieved from https://ojs.unm.ac.id/sainsmat/article/viewFile/1119/307

Naimnule, L., & Corebima, A. D. (2018). The correlation between metacognitive skills and critical thinking skills toward students ' process skills in biology learning. *Journal of Pedagogical Research*, *2*(2), 122–134. https://ijopr.com

Nusantari, E. (2012). Perbedaan pemahaman awal tentang konsep genetika pada siswa, mahasiswa, guru, dan dosen. *Jurnal Ilmu Pendidikan*, *18*(2), 244–252. Doi: https://doi.org/10.17977/jip.v18i2.3627

Nyamupangedengu, E., & Lelliott, A. (2018). Planning for teaching a genetics course to pre-service teachers: experiences of a biology teacher educator. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(3), 308–318. Doi: https://doi.org/10.1080/18117295.2018.1539325

Orcajo, T. I., & Aznar, M. M. (2005). Solving problems in genetics ii: conceptual restructuring. *International Journal of Science Education*, *27*(12), 1495–1519. Doi: https://doi.org/10.1080/09500690500186584

Panchu, P., Bahuleyan, B., Seethalakshmi, K., & Thomas, T. (2016). Metacognitive knowledge : a tool for academic success. *International Journal of Medical Research Professionals*, *2*(5), 3–6. Doi: https://doi.org/10.21276/ijmrp.2016.2.5.026

Pearson, J. T., & Hughes, W. J. (1986a). Designing an a-level genetics course: i, identifying the necessary concepts and considering their relationships. *Journal of Biological Education*, *20*(1), 47–55. Doi: https://doi.org/10.1080/00219266.1986.9654776

Pearson, J. T., & Hughes, W. J. (1986b). Designing an a-level genetics course: ii sequencing the material and developing a strategy for teaching and assessment. *Journal of Biological Education*, *20*(2), 133–137. Doi: https://doi.org/10.1080/00219266.1986.9654800

Prayogi, S., Yuanita, L., & Wasis, W. (2017). Critical-inquiry-based-learning: Model of learning to promote critical thinking ability of pre-service teachers. *IOP Conference Series: Journal of Physics*, *947*(1). Doi: https://doi.org/10.1088/1742-6596/947/1/012013

Ramdiah, S., Abidinsyah, Royani, M., & Husamah. (2019). Understanding, planning, and implementation of HOTS by senior high school biology teachers in Banjarmasin-Indonesia. *International Journal of Instruction*, *12*(1). Retrieved from http://www.e-iji.net/dosyalar/iji_2019_1_28.pdf

Reece, G. J. (2005). Critical thinking and cognitive transfer: implications for the development of online information literacy tutorials. *Research Strategies*, *20*(4), 482–493. Doi: https://doi.org/10.1016/j.resstr.2006.12.018

Scott, C. L. (2015). *The futures of learning 2: What kind of learning for the 21st century? Education Research and Foresight*. Paris. Retrieved from https://www.researchgate.net/profile/Dickson_Adom/post/How_to_develop_self_learning_skills_techniques_and_processes/attachment/5a8fa082b53d2f0bba53ba01/AS%3A597062399840261%401519362177920/download/242996e.pdf

Stern, F., & Kampourakis, K. (2017). Teaching for genetics literacy in the post-genomic era. *Studies in Science Education*, *53*(2), 193–225. Doi: https://doi.org/10.1080/03057267.2017.1392731

Stupple, E. J. N., Maratos, F. A., Elander, J., Hunt, T. E., Cheung, K. Y. F., & Aubeeluck, A. V. (2017). Development of the critical thinking toolkit (CriTT): A measure of student attitudes and beliefs about critical thinking. *Thinking Skills and Creativity*, *23*, 91–100. Doi: https://doi.org/10.1016/j.tsc.2016.11.007

Tamsyani, W. (2016). Pengaruh model pembelajaran dan kesadaran metakognitif terhadap hasil belajar peserta didik SMA dalam materi pokok asam basa. *Journal of EST*, *2*(April), 10–25. Doi: https://doi.org/10.26858/est.v2i1.1887

Topçu, M. S., & Şahin-Pekmez, E. (2009). Turkish middle school students' difficulties in learning genetics concepts. *Journal of Turkish Science Education*, *6*(2), 55–62. Retrieved from http://www.tused.org/internet/tused/archive/v6/i2/text/tusedv6i2s5.pdf

Tsui, C., & Treagust, D. F. (2005). Conceptual change in learning genetics: an ontological perspective. *Research in Science & Technological Education*, *22*(2), 185–202. Doi: https://doi.org/10.1080/0263514042000290895

Tzohar-Rozen, M., & Kramarski, B. (2014). Metacognition, motivation, and emotions: contribution of self-regulated learning to solving mathematical problems. *Global Education Review*, *1*(4), 76–95. Retrieved from https://ger.mercy.edu

Wahyono, P., Hindun, I., Muizzudin, M., & Miharja, F. J. (2016). Implementasi pembelajaran lesson study pada mata kuliah genetika lanjut. *JINoP (Jurnal Inovasi Pembelajaran)*, *2*(2), 400-406. Doi: https://doi.org/10.22219/jinop.v2i2.3493

Yilmaz, D., Tekkaya, C., & Sungur, S. (2011). The Comparative effects of prediction/discussion-based learning cycle, conceptual change text, and traditional instructions on student understanding of genetics. *International Journal of Science Education*, *33*(5), 607–628. Doi: https://doi.org/10.1080/09500691003657758

Zubaidah, S., Corebima, A. D., & Mistianah. (2015). Asesmen berpikir kritis terintegrasi tes essay. In *Symbion: Symposium on Biology Education* (pp. 200–213). Jogjakarta: Universitas Ahmad Dahlan. Retrieved from https://drive.google.com/file/d/0B4keDkb86kWpd0xRTjFlYVBjcEE/view