Research Article

Critical thinking skills: The academic ability, mastering concepts, and analytical skill of undergraduate students

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ABSTRACT

Science and technology development in the 21st-Century has been demanding educators to provide learning activities which stimulate students' critical thinking skills. This study aimed to find out the correlated factors of the students' critical thinking skills as well as of which was the strongest determinant in leveling the skills. The subject of this correlational research was 112 undergraduate students in the Department of Biology Education, Universitas Muhammadiyah Malang who took Botany course. There were four variables measured in this study, namely academic ability, mastering concepts, analytical skill, and critical thinking skills. The data of academic ability was obtained from students' cumulative index in the previous semester while the three other variables were measured using final exam test. All the variables then analyzed using multiple linear regression. The results showed that the three predictor variables (mastering concepts, academic ability, and analytical skill) gave effective contributions toward students' critical thinking skills, with the percentages of 3.84%, 32.25%, and 54.26% respectively. Therefore, the results of this study could be a basic reference in designing learning process which empower the students' critical thinking skills.

INTRODUCTION

Rapidly developing of science and technology in the 21st-Century bring changes in daily life (Benešová & Tupaa, 2017; Hartmann & Bovenschulte, 2013; Osman, Hamid, & Hassan, 2009; Pfeiffer, 2015; Turiman, Omar, Daud, & Osman, 2012). The young generation is faced with the rapid developing of science and technology in industry 4.0 revolution era, so they must have the ability to adapt with these developments (Agolla, 2018; Hartmann & Bovenschulte, 2013; Turiman et al., 2012). Consequently, the educator must prepare students to compete with others (Agolla, 2018; Bell, 2010; Darling-hammond, 2014; Mangena & Chabeli, 2005). Students should be able to master the basic concepts in the learning content. They need

assistance in understanding concepts because learning with understanding involves more than just adding new concepts and processes to existing knowledge; it also involves conceptual change and the creation of integrated knowledge structures. Furthermore, educators should empower a variety of higher-order thinking skill (HOTS) during the learning process. Higher-order thinking involves the learning of complex judgmental skills such as critical thinking and problem solving (Heong et al., 2011; Magsino, 2014; Tofade, Elsner, & Haines, 2013). Without such skills, they will lose competitiveness in this globalization era (Trilling & Fadel, 2009).

Critical thinking skills belong to higher-order thinking skills that need to be empowered in today's educational process (Phan, 2010). Critical thinking skills could be defined as logical and reflective thinking skills that focus on determining what must be done (Ennis, 2011; Karakoç, 2016; Radulović & Stančić, 2017). An individual who has the ability to think critically are able to see and solve problems (Ghazivakili et al., 2014; Heong et al., 2011; Magsino, 2014; Tofade et al., 2013; Ulger, 2018). Through the empowerment of these skills, students will be facilitated to become individuals who tend to have focus, find the reason, and conduct a comprehensive analysis to make a conclusion and solving a problem (Finken & Ennis, 1993; Karakoç, 2016; Ulger, 2018).

Moreover, critical thinking skills are widely known as essential skills (Bahr, 2010; Bell, 2010; Karakoç, 2016). Graduates students without critical thinking skills will have difficulty competing in the work environment and in the midst of society (Takeda, 2016; Talat & Chaudhry, 2014). It is no wonder most educators consider that this skill is the most desirable goal of the learning process in school. Empowering critical thinking skills is not only limited to primary and secondary education level but also important in the college education level (Heong et al., 2011).

Botany is one of the subjects in the Department of Biology Education at the Faculty of Teacher Training and Education (FTTE), Universitas Muhammadiyah Malang (UMM), East Java Province-Indonesia. This course is normally taken by students of 2nd semester. The various factors in this course are estimated to be correlated with the students' critical thinking skills level. One of these factors is the analytical skill of article analysis. According to Ghazivakili et al., (2014), Irwanto, Rohaeti, Widjajanti, and Suyanta (2017) analytical skill is an activity that encourages students to evaluate some information they get. Through this activity, the student will be trained to think critically about the articles they obtained. Analytical skills refer to the ability to collect and analyze information, problem-solve, and make decisions (Ghazivakili et al., 2014; Phan, 2010). Beside analytical skill, another factor considered to be related to critical thinking skills is mastering concepts. Several studies reported that the mastering concepts ability has a relationship with students' critical thinking skill level (Alatas, 2014; Chukwuyenum, 2013; Herayanti & Habibi, 2013; Radulović & Stančić, 2017). In activities that trigger critical thinking, students are better able to understand something has occurred. This deeper understanding allows students to better analyze the circumstances surrounding the occurrence and differing point of view about the occurrence (Tsai, Chen, Chang, & Chang, 2013).

The various factors are estimated to be correlated with the students' critical thinking skill, not only analytical skill and mastering concepts, but also academic ability. In some previous studies Karmana (2011) and Mamu (2014), academic ability is seen as one of the factors likely to affect students' critical thinking skills. An individual with high academic ability tends to have good critical thinking skills, whereas low academic students tend to lack critical thinking skills (Setiawati & Corebima, 2017). Karbalaei (2012) argues that a strong critical thinking pedagogy that encourages students' critical knowledge, skills, and dispositions may improve students' academic success. However, according to Kanbay (2017), there is no relationship between critical thinking skill with academic achievement. The improvement of academic achievement proceeded to the next grade. Thus, the focus of this study is to find out what factors are correlated with the critical thinking skills of students in Botany class. This study will also want to find out which factors are the most determinant in determining the students' critical thinking skills level. Therefore, the result of this study could be a basic reference or consideration in designing the learning process that is able to empower the critical thinking skills of students.

METHOD

The correlational research was conducted in the Department of Biology Education, FTEE, UMM, East Java Province-Indonesia. This research was involving 112 undergraduate students in the Department of Biology Education, UMM. All the students who take Botany class were chosen as the research subject. There were four variables measured in this study, namely academic ability (AA), mastering concepts (MC), analytical skill (AS), and critical thinking skills. The data of academic ability was obtained from students' grade point in the previous semester. The data of concepts' mastery was obtained from Botany final exam score. The data of critical level of article analysis was obtained from critical analysis task score which students were ordered to analyze the scientific article critically. The scientific articles used were related to ecology role of algae (Cyanophyta,

Rhodophyta, Chlorophyta, Diatom, and Phaeophyta), mold (slime and water mold), fungi (Zygomycota, Ascomycota, Basidiomycota, and Deuteromycota), and Bryophyta (liverwort, hornwort, and mosses) in environmental. The critical thinking skills data was obtained from the students' final exam answers. The final exam was designed as a question that facilitates the students to think in higher-order level and consisting of four analysis questions (essay). From these answers, the students' critical thinking skills level was accessed by using a critical thinking rubric developed by Zubaidah, Corebima, and Mistianah (2015), showed in Table 1. The rubric was developed according to characteristic of critical thinking skills (Ennis, 2011; Finken & Ennis, 1993).

Table 1. Critical thinking rubric for essay test

Score	Descriptor
5	- The all concepts are correct, clear, and specific - The all answer elaborations are correct, clear, specific, and supported with strong, correct, and clear argument(s) - The thinking plot is good, the all concepts are linked and integrated - The language used is good and correct - The all aspects appear, the evidences served are good and balance
4	- Most of the concepts are correct, clear, and less specific - Most of the answer elaborations are correct, clear, and less specific - The thinking plot is good, the all concepts are linked and integrated - The language used is good and little mistake(s) - The all aspects appear, but unbalance
3	- The small part of the concepts is correct and clear - The small part of the answer elaborations is correct and clear, but the reason and argument undergirding are unclear - The thinking plot is good enough, and small parts are linked - The language used is good enough, and there are small wrong spellings - Most of the aspects appeared are likely correct
2	- The concepts are less focus or extravagant or doubtful - The answer elaborations were less supporting - The plot is less good, the concepts are unlinked - The language used is good, the sentences are incomplete - The small parts of aspects appeared are likely correct
1	- The all concepts are incorrect - The reasons are incorrect - The thinking plot is bad - The language used is bad - The all aspects are inadequate
0	No answer or the answer is incorrect

All the variables then tested by multiple linear regression ($\alpha= 0.05$). Before multiple linear regression tests were performed, the data were tested using classical assumption tests: Shapiro-Wilk test to see the normality of data, Durbin-Watson test to determine the presence of autocorrelation, as well as multicollinearity test. Furthermore, the data also tested using Analysis of Variance (ANOVA) to find out whether the predictor (variables) significantly has a relationship with the criteria (critical thinking skills). The multiple linear regression used to find the multiple correlation coefficients to show how big the contribution of the variable measured toward critical thinking skills. These coefficients were used to determine the linear regression line.

RESULTS AND DISCUSSION

Classical assumption tests

The result of the Shapiro-Wilk test showed that the data have a normal distribution (Table 2). While the Durbin-Watson test revealed that the data have negative autocorrelation (Table 3) and also no multicollinearity (Table 4). Therefore, the data can be analyzed using multiple regression test.

Table 2. The result of Shapiro-Wilk test (normality)

	Shapiro-Wilk		
	Statistic	df	Sig.
Unstandardized Residual	0.981	112	0.114

Table 3. The result of Durbin-Watson test (autocorrelation)

Model	Durbin-Watson
1	2.058

Table 4. The result of Durbin-Watson test (collinearity)

Model	Collinearity Statistics	
	Tolerance	VIF
1 (Constant)		
AA	0.714	1.401
AS	0.844	1.185
MC	0.654	1.529

Hypothesis testing

Table 5 shows the results of the ANOVA to find out whether the predictor significantly has a relationship with the criteria or not. Based on Table 5, the F statistic is 336,559 with P-value < α (0.05). Consequently, it can be concluded that academic ability, analytical skill, and mastering concepts significantly have a relationship with students' critical thinking skills in Botany class.

Table 5. The result of ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	38290.021	3	12763.340	336.559	0.00[b]
Residual	4095.693	108	37.923		
Total	42385.714	111			

a. Dependent variable: critical thinking skills
b. Predictors: (Constant), AA, AS, MS

Table 6 presents the summary of the correlation results whether there is a relationship between all predictors and criteria. Column R in Table 6 is a multiple correlation coefficient, while R square is a value of determination.

Table 6. The summary of the correlation result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.950[a]	0.903	0.901	6.15817

a. Predictors: (Constant), AA, AS, MS

Based on Table 6, the R statistic is equal to 0.950, it means that there is a strong correlation between the three predictors and the criteria. Beside that R square is 0.903, information that can be obtained is academic ability, analytical skill, and mastering concepts have contributing 90.3% in explaining the students' critical thinking skills in Botany class, while 9.7% of the results are explained by other variables. The relative contribution and effective contribution for each predictor of the criteria are presented in Table 7.

Table 7. The relative and effective contribution result

Predictor	Relative Contribution	Effective Contribution
AA	35.69	32.25
AS	60.06	54.26
MC	4.25	3.84
Total	100	90.34

Based on Table 7, the effective contribution of academic ability is 32.25%, analytical skill is 54.26%, whereas mastering concepts amounted to 3.84%. Thus, the three variables made an effective contribution of up to 90.34%. The result regression coefficient to show how big the contribution of the variable measured toward critical thinking skills is showed in Table 8. Moreover, the linear regression line based on the regression coefficient is described in Equation (1).

Table 8. The result of regression coefficients

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	Beta	Std. Error	Beta		
1 (Const.)	-26.428	9.913		-2.666	0.009
AA	5.148	2.921	0.062	1.762	0.081
AS	.039	0.047	0.027	0.817	0.416
MC	.952	0.039	0.905	24.476	0.000

a. Dependent Variable: critical thinking skill

$$Y = 26.428 + 5.148X_1 + 0.039X_2 + 0.925X_3 \tag{1}$$

Students' critical thinking skills become an essential goal in education. It is related to a perceived need to deal with the information explosion in this era. However these skills are neither inborn nor naturally acquired, yet must be trained in students (Changwong, Sukkamart, & Sisan, 2018; Mangena & Chabeli, 2005; Su, Ricci, & Mnatsakanian, 2016; Suarniati, Hidayah, & Handarini, 2018; Ulger, 2018; Visande, 2014; Zabit, 2010). Based on equation (1), the result indicated that analytical skill has the highest contribution to students' critical thinking skills. Students who can think critically must often train themselves to analyze a problem. One of the learning activities in Botany class requires students to analyze information (e.g. research articles) related to algae, fungi, and bryophytes. According to Phan (2010) this activity accommodating students' ability to interpret and evaluate information presented to them and determine whether the information (printed and online) is valid or not. Furthermore, students solve the problem related to the information in their final exam. Bahr (2010) convey that this assessment helps provide evidence of whether students can reason analytically. They were forced to write their explanation based on their analysis. Some previous study agrees that this activity habituates students to make critical analyses of the problem they deal with while strengthening their critical thinking skills (Abdullah, Parris, Lie, Guzdar, & Tour, 2015; Phan, 2010). For the reason that analytical thinking is one of the most important aspect of critical thinking skills (Caroselli, 2009) and very crucial for graduate students who often to become researchers (Abdullah et al., 2015; Phan, 2010).

As well as analytical skill, the academic ability also contributes effectively to students' critical thinking skills (32.25%) as served in Table 7. In line with some previous research showed that an individual with high academic ability tends to have good critical thinking skills, and vice versa (Karagöl & Bekmezci, 2015; Setiawati & Corebima, 2017). Academic ability is related to an individual's beliefs and self-evaluations regarding the nature of their skills and abilities. This is also related to students' personal views about how skills and abilities in their work, including when they solve the problem in their exam. This student's academic ability is also closely related to academic motivation (Shim & Walczak, 2012) and academic maturity (Toppin & Chitsonga, 2016). When students have high academic abilities, they will be encouraged and motivated to analyze information (e.g. problems) critically. This means that students with high abilities showed high performance in solving problems (Karbalaei, 2012), which is become particularly aspect of students' critical thinking skills. It is obvious that academic ability correlates with critical thinking skills.

Furthermore, the other predictor which has the lowest contribution (4.25%) to students' critical thinking skills is mastering concepts ability (Table 7). However several studies showed that students' understanding of the learning concepts is strongly responsible for the high critical skills of students (Alatas, 2014; Herayanti & Habibi, 2013; Setiawati & Corebima, 2017). Students who can understand concepts usually have a high literacy of reading/ information. They are used to obtain information from various sources, then writing their understanding of it and also assessing whether the information is relevant to the problem, and finally using the right information to determine the problem-solving (Donnelly & Fitzmaurice, 2011; Sorensen et al., 2012). For that reason, mastering concepts ability becomes one factor in charge of the students' critical thinking skills maturation.

Based on the discussion, there is a correlation between all of three predictors (analytical skill, academic ability, and mastering concepts) to students' critical thinking skills and the linear regression line can be seen in Equation (1). This result could be a basic reference in designing the learning process which is able to empower the critical thinking skills of students. For example, educators can accommodate students' critical skill using the scientific process (Gultepe, 2016), such as problem-based learning (Birgili, 2015; Ulger, 2018; Zabit, 2010).

CONCLUSION

The all of three variables, mastering concepts, academic ability, and analytical skill have an effective contribution toward students' critical thinking skills, with the percentage 3.84%, 32.25%, and 54.26% respectively. The student's analytical skill has the highest contribution to their critical thinking skills. Therefore, the result of this study could be a basic reference in designing the learning process which is able to empower the critical thinking skills of students, such as accommodating their skill in problem-based learning.

REFERENCES

Abdullah, C., Parris, J., Lie, R., Guzdar, A., & Tour, E. (2015). Critical analysis of primary literature in a master's-level class: Effects on self-efficacy and science-process skills. *CBE Life Sciences Education*, *14*, 1–13. doi: https://doi.org/10.1187/cbe.14-10-0180

Agolla, J. E. (2018). Human capital in the smart manufacturing and industry 4.0 revolution. In A. Petrillo, R. Cioffi, & F. De Felice (Eds.), *Digital Transformation in Smart Manufacturing* (pp. 41–58). doi: https://

doi.org/10.5772/intechopen.73575

Alatas, F. (2014). Hubungan pemahaman konsep dengan keterampilan berpikir kritis melalui model pembelajaran Treffinger pada mata kuliah Fisika Dasar. *Edusains*, *6*(1), 88–96. doi: https://doi.org/10.15408/es.v6i1.1103

Bahr, N. (2010). Thinking critically about critical thinking in higher education. *International Journal for the Scholarship of Teaching and Learning*, *4*(2), 1–16. doi: https://doi.org/10.20429/ijsotl.2010.040209

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *83*(2), 39–43. doi: https://doi.org/10.1080/00098650903505415

Benešová, A., & Tupaa, J. (2017). Requirements for education and qualification of people in Industry. In *27th International Conference on Flexible Automation and Intelligent Manufacturing* (Vol. 11, pp. 2195–2202). doi: https://doi.org/10.1016/j.promfg.2017.07.366

Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity*, *2*(2), 71–80. doi: https://doi.org/10.18200/JGEDC.2015214253

Caroselli, M. (2009). *50 activities for developing critical thinking skills*. Amherst, Massachusetts: HRD Press. Retrieved from http://spers.ca/wp-content/uploads/2013/08/50-activities-for-developing-critical-thinking-skills.pdf

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, *11*(2), 37–48. doi: https://doi.org/10.14254/2071

Chukwuyenum, A. N. (2013). Impact of critical thinking on performance in mathematics among senior secondary school students in Lagos State. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *3*(5), 18–25. Retrieved from http://www.iosrjournals.org/iosr-jrme/papers/Vol-3Issue-5/D0351825.pdf

Darling-hammond, L. (2014). Constructing 21st-century teacher education. *Journal of Teacher Education*, *57*(3), 300–314. doi: https://doi.org/10.1177/0022487105285962

Donnelly, R., & Fitzmaurice, M. (2011). Crucial connections: An exploration of critical thinking and scholarly writing. In C. Horvarth & J. Forte (Eds.), *Critical Thinking* (pp. 159–174). New York: Nova Science Publisher. Retrieved from https://arrow.dit.ie/cgi/viewcontent.cgi?article=1003&context=ltcbk

Ennis, R. H. (2011). The nature of critical thinking: An outline of critical thinking dispositions and abilities. In *Sixth International Conference on Thinking at MIT, July 1994*. Cambridge, MA. Retrieved from https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking_51711_000.pdf?sfvrsn=7bb51288_2

Finken, M., & Ennis, R. H. (1993). *Illinois critical thinking essay test*. Champaign. Retrieved from http://evolkov.net/critic.think/tests/IllCTEssayTestFinken-Ennis12-1993LowR.pdf%0A%0AMakeGoogle view image button visible again: https://goo.gl/DYGbub

Ghazivakili, Z., Norouzi Nia, R., Panahi, F., Karimi, M., Gholsorkhi, H., & Ahmadi, Z. (2014). The role of critical thinking skills and learning styles of university students in their academic performance. *Journal of Advances in Medical Education & Professionalism*, *2*(3), 95–102. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4235550/

Gultepe, N. (2016). High school science teachers' views on science process skills. *International Journal of Environmental and Science Education*, *11*(5), 779–800. doi: https://doi.org/10.12973/ijese.2016.348a

Hartmann, E. A., & Bovenschulte, M. (2013). Skills needs analysis for "Industry 4.0" based on roadmaps for smart systems. In SKOLKOVO (Ed.), *Using Technology Foresights for Identifying Future Skills Needs. Global Workshop Proceedings* (pp. 24–36). Moscow. Retrieved from https://www.iit-berlin.de/de/publikationen/skills-needs-analysis-for-industry-4-0201d-based-on-roadmaps-for-smart-systems/at_download/download

Heong, Y. M., Othman, W. B., Yunos, J. Bin, Kiong, T. T., Hassan, R. Bin, Mohaffyza, M., & Mohamad, B. (2011). The level of Marzano higher order thinking skills among technical education students. *International Journal of Social Science and Humanity*, *1*(2), 121–125. Retrieved from http://ijssh.org/papers/20-H009.pdf

Herayanti, L., & Habibi. (2013). Korelasi penguasaan konsep dan berpikir kritis mahasiswa dengan menggunakan model pembelajaran berbasis masalah berbantuan simulasi komputer. *Jurnal Kependidikan*, *12*(2), 155–159. Retrieved from http://lppm.ikipmataram.ac.id/wp-content/uploads/2015/03/Lovy-Herayanti-dan-Habibi.-Korelasi-Penguasaan-Konsep-dan-Berpikir-Kritis-Mahasiswa.-Jurn

al-Kependidikan-Edisi-November-2013-Vol.-12-No.-2.pdf

Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. (2017). Students' science process skill and analytical thinking ability in chemistry learning. In *AIP Conference Proceedings 1868,* (Vol. 1868, pp. 1–4). American Institute of Physics Articles. doi: https://doi.org/10.1063/1.4995100

Kanbay, Y., Isik, E., Aslan, Ö., Tektas, P., & Kiliç, N. (2017). Critical thinking skill and academic achievement development in nursing students: Four-year longitudinal study. *American Journal of Educational Research and Reviews*, *2*(12), 1–10. Retrieved from https://escipub.com/Articles/AJERR/AJERR-2017-12-0501

Karagöl, İ., & Bekmezci, S. (2015). Investigating academic achievements and critical thinking dispositions of teacher candidates. *Journal of Education and Training Studies*, *3*(4), 86–92. doi: https://doi.org/10.11114/jets.v3i4.834

Karakoç, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science*, *6*(7), 81–84. Retrieved from http://www.ijhssnet.com/journals/Vol_6_No_7_July_2016/10.pdf

Karbalaei, A. (2012). Critical thinking and academic archievement. *Ikala*, *17*(2), 121–128. Retrieved from http://www.redalyc.org/articulo.oa?id=255024132001

Karmana, I. W. (2011). Strategi pembelajaran, kemampuan akademik, kemampuan pemecahan masalah, dan hasil belajar biologi. *Jurnal Ilmu Pendidikan*, *17*(5), 378–386. doi: https://doi.org/10.17977/jip.v17i5.2866

Magsino, R. M. (2014). Enhancing higher order thinking skills in a marine biology class through Problem-Based Learning. *Asia Pacific Journal of Multidisciplinary Research*, *2*(5), 1–6. Retrieved from http://www.apjmr.com/wp-content/uploads/2014/09/APJMR-2014-2-116.pdf

Mamu, H. D. (2014). Pengaruh strategi pembelajaran, kemampuan akademik dan interaksinya terhadap keterampilan berpikir kritis dan hasil belajar kognitif IPA Biologi. *Jurnal Pendidikan Sains*, *2*(1), 1–11. Retrieved from http://journal.um.ac.id/index.php/jps/

Mangena, A., & Chabeli, M. M. (2005). Strategies to overcome obstacles in the facilitation of critical thinking in nursing education. *Nurse Education Today*, *25*(4), 291–298. doi: https://doi.org/10.1016/j.nedt.2005.01.012

Osman, K., Hamid, S. H. A., & Hassan, A. (2009). Standard setting: Inserting domain of the 21st century thinking skills into the existing science curriculum in Malaysia. *Procedia - Social and Behavioral Sciences*, *1*(1), 2573–2577. doi: https://doi.org/10.1016/j.sbspro.2009.01.454

Pfeiffer, S. (2015). *Effects of Industry 4.0 on vocational education and training*. (I. of T. A. (ITA), Ed.). Vienna: Austrian Academy of Sciences (ÖAW). Retrieved from http://epub.oeaw.ac.at/ita/ita-manuscript/ita_15_04.pdf

Phan, H. P. (2010). Critical thinking as a self-regulatory process component in teaching and learning. *Psicothema*, *22*(2), 284–92. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/20423634

Radulović, L., & Stančić, M. (2017). What is needed to develop critical thinking in schools? *CEPS Journal*, *7*(3), 9–25. Retrieved from https://files.eric.ed.gov/fulltext/EJ1156618.pdf

Setiawati, H., & Corebima, A. D. (2017). Empowering critical thinking skills of the students having different academic ability in biology learning of senior high school through PQ4R - TPS strategy. *The International Journal of Social Sciences and Humanities Invention*, *4*(5), 3521–3526. doi: https://doi.org/10.18535/ijsshi/v4i5.09

Shim, W.-J., & Walczak, K. (2012). The impact of faculty teaching practices on the development of students' critical thinking skills. *International Journal of Teaching and Learning in Higher Education*, *24*(1), 16–30. Retrieved from http://www.isetl.org/ijtlhe/pdf/IJTLHE1128.pdf

Sorensen, K., S, V. D. B., Fullam, J., Doyle, G., Pelikan, J., Slonska, Z., … European, H.-E. C. H. L. P. (2012). Health literacy and public health: A systematic review and integration of definitions and models. *BMC Public Health*, *12*(1), 80. doi: https://doi.org/10.1186/1471-2458-12-80

Su, H. F. H. "Angie," Ricci, F. A., & Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *International Journal of Research in Education and Science (IJRES)*, *2*(1), 190–200. Retrieved from https://eric.ed.gov/?id=EJ1105157

Suarniati, N. W., Hidayah, N., & Handarini, D. (2018). The development of learning tools to improve students' critical thinking skills in vocational high school. In *IOP Conference Series: Earth and Environmental Science* (Vol. 175, pp. 1–7). doi: https://doi.org/10.1088/1755-1315/175/1/012095

Takeda, I. (2016). Report: Project-based learning with 21st century skills for the Japanese language classroom. *Journal of Integrated Creative Studies*. Retrieved from http://www2.yukawa.kyoto-u.ac.jp

/~future/wp-content/uploads/2017/12/2016-020-e.pdf

Talat, A., & Chaudhry, H. F. (2014). The effect of PBL and 21st century skills on students' creativity and competitiveness in private schools. *The Lahore Journal of Business*, *2*(2), 89–114. Retrieved from http://www.lahoreschoolofeconomics.edu.pk/businessjournals/V2issue2/05TalatandChaudhry FINAL.pdf

Tofade, T., Elsner, J., & Haines, S. T. (2013). Best practice strategies for effective use of questions as a teaching tool. *American Journal of Pharmaceutical Education*, *77*(7), 1–9. doi: https://doi.org/10.5688/ajpe777155

Toppin, I. N., & Chitsonga, S. (2016). Critical thinking skills and academic maturity: Emerging results from a five-year Quality Enhancement Plan (QEP) study. *Journal of Inquiry & Action in Education*, *7*(2), 81–93. Retrieved from https://files.eric.ed.gov/fulltext/EJ1133548.pdf

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. San Francisco, CA, US: Jossey-Bass. Retrieved from https://psycnet.apa.org/record/2009-18745-000

Tsai, P.-Y., Chen, S., Chang, H.-P., & Chang, W.-H. (2013). Effects of prompting critical reading of science news on seventh graders' cognitive achievement. *International Journal of Environmental & Science Education*, *8*(1), 85–107. Retrieved from http://www.ijese.net/makale/1562

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. doi: https://doi.org/10.1016/j.sbspro.2012.09.253

Ulger, K. (2018). The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education. *Interdisciplinary Journal of Problem-Based Learning*, *12*(1). doi: https://doi.org/10.7771/1541-5015.1649

Visande, J. C. (2014). Developing critical thinking skills among education students through formative education. *International Journal for Cross-Disciplinary Subjects in Education (IJCDSE)*, *5*(4), 1783–1789. Retrieved from https://infonomics-society.org/wp-content/uploads/ijcdse/published-papers/volume-5-2014/Developing-Critical-Thinking-Skills-among-Education-Students-.pdf

Zabit, M. N. M. (2010). Problem-based learning on students' critical thinking skills in teaching business education in Malaysia: A literature review. *American Journal of Business Education*, *3*(6), 19–32. Retrieved from https://files.eric.ed.gov/fulltext/EJ1058610.pdf

Zubaidah, S., Corebima, A. D., & Mistianah. (2015). Asesmen berpikir kritis terintegrasi tes essay. In *Symbion: Symposium on Biology Education* (pp. 200–213). Yogyakarta: Universitas Ahmad Dahlan. Retrieved from https://www.researchgate.net/publication/322315188_Asesmen_Berpikir_Kritis_Terintegrasi_Tes_Essay