Critical Thinking Skills Reviewed from Logical-Mathematical and Musical Intelligence on Process Oriented Guided Inquiry Learning

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Article Info	Abstract
	This research aims to describe critical thinking skill reviewed from *logical-mathematical* and *musical intelligence.* This *mix method* research used *sequential explanatory* design. The subjects consisted of 35 X AKL3 students of Islamiyah VHS, Sapugarut, Pekalongan municipality, in academic year 2019/2020. They were selected based on categories, such as high *logical -mathematical intelligence* and *low musical intelligence,* low *logical - mathematical intelligence* and *high musical intelligence,* and high *logical - mathematical* and *musical intelligences.* The findings showed that the students' mathematics critical students with high *logical-mathematical* and low *musical intelligence* met all indicators of interpreting problem, applying solution, evaluating solution, and concluding the results by using facts. The students' mathematics critical thinking skill with low *mathematical intelligence* and high *musical intelligence* met all indicators of interpreting problems, applying solution, and evaluating the solution. The mathematics critical thinking skill of students with high *logical-mathematical* and *musical intelligence* could met all indicators of interpreting problems, applying solution, evaluating solution, and concluding the results by using facts.

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INTRODUCTION

Indonesia is a resourceful country with natural resource but it is still not optimized properly. It is due to low human resource quality and it influences on natural sector which is dominated by foreign parties. Thus, the numbers of unemployments in Indonesia are still high. According to Statistics Agency (2018), the rate of unemployment in Indonesia is 5.34%. Based on the educational level, the unemployment rate of Vocational High School student still dominates among other educational levels with 11.24%

Such high rate is still correlated to Indonesian educational system which is still low and is lack of capability to create reliable and competent graduates in working world; moreover Indonesia has agreed and signed South-East Asia Economic Community (AEC) or MEA. AEC is an integration of South-East Asia economy in facing free trading among its members and makes it as single market and production base in which flows of goods, services, capital flow investment, and skillful workers could move freely even in Indonesia.

Students should be taught to thinking critically in facing global competition. It is in line with competences needed by 21st century students. According to BSNP, they are critical thinking skill and problem solving skill. Agoestanto, Sukestiyarno, and Rochmad (2017) asserted that critical thinking is an important thing in daily life to keep survives.

According to Ennis (2011), Fisher (2008), and Bassam (2013), critical thinking skill is a process to use reasoning skill rationally, reflectively, and comprehensively to take and make logical and brilliant decisions about what to believe and what to do, to identify, to analyze, and to evaluate argument. Glaser (in Widyaningtyaw, 2015) emphasized that critical thinking skill is skill involving prior knowledge, reasoning, and cognitive strategy to generalize, prove, or evaluate an previous unknown mathematics effectively. This definition is supported by Facione (in Nursyahidah, 2018) that the basic skill in critical thinking consists of interpreting, analyzing, evaluating, concluding, explaining, and self-monitoring skills.

Critical thinking is important to master by students in arranging certain argument or opinion to take decision. According to Udi (2015), Koriyah and Idris (2015), and Rachmantika (2019), critical thinking skill benefits, in long term, embodies into students' supports to manage their learning skills and empower individuals in analyzing and evaluating information in a better way to improve students' achievements.

According to research done at Islamiyah VHS, Sapugarut, it showed that the students' critical thinkings were low. According to the observation and initial test of critical thinking skill, from 204 students of X grade, the test results passing actual accomplishment was 36% from all X graders. It meant 64% the result of the test had not been passing the actual accomplishment grade. It was caused by lack of critical thinking skill teaching done in the class and the teacher still used conventional method in the learning. It was revealed in Widiantiri et al (2016:3) that low critical thinking skill is caused by teacher's preference to use conventional method. Thus, it leads to passive learning.

In the implementation of process oriented guided inquiry learning model (POGIL) was found to be more effective in improving students' critical thinking skill (Zamista, 2015). POGIL is a learning model combining guided inquiry and cooperative approach where teacher provides examples of specific topics and assists students to understand the concept (Eggen: 2012). Furthermore, Brickman (in Uswatun, 2015) stated that inquiry-based learning is a learning by implementing student centered learning strategy. Guided inquiry is useful to improve critical thinking skill of students as proven by Karim (2011) and Villagonzalo (2014). They revealed that students taught by guided inquiry would have better critical thinking and performance than those taught conventionally. Send and Yilmaz (in Yunia et al, 2016), POGIL learning model is a learning model which directs students to construct their knowledge by themselves through active participation. Studies done by Susana, Kadaritna, and Tania (2018) stated that POGIL learning model was effective to improve critical thinking skill on chemical equilibrium.

The prioritized learning model in 2013 curriculum implementation may cover Problem Based Learning According to Abdurazak (2016), PBL is a learning model presenting various authentic problem

situation which function for students so the problems could be used as milestone to conduct investigation and research. Therefore, PBL requires students to construct their knowledge through problems. Daily life based learning will be easier to be understood by students. Isrokatun (2018: 44) stated that learning conducted based on daily life problem would make students easier to understand and implement mathematics in their daily lives. The model requires students to be active. However, the reality shows that the teacher is active while the students remain passive.

In POGIL learning model and PBL, there are group discussion syntax which is influenced by verbal skill (Tyasning, 2015: 41). In POGIL and PBL implementation, both of them require teachers' guidances. These guidance in the models exist in each phase or stage. The stages in PBL model are direct assistance based on material in which is different to POGIL model. Teacher's guidance in POGIL embodies into guiding questions to make students critically and analytically thinking so that they are more independent than those taught by PBL model. It could be concluded that POGIL is better than PBL if it is implemented to improve students' skills.

One of the solutions to develop High Order Thinking Skill is through intelligence owned by students. The concerned intelligence is compound intelligence (Leonard, 2018). Compound intelligence consists of 9 intelligences (Amstrong, 2009). They are logical-mathematical intelligence and musical intelligence. Those two intelligence are important factors in learning success as stated by Leonard and Nanda (2018: 196) logical-mathematical intelligence emphasizes on question solving by using logic which requires students to think and analyze first upon the existing problems Luiz (in Hermiyati, 2015) stated that learning music could be a medium to improve mathematics skill. Boyd (2013) stated that there was positive correlation between students' participations in musics and their achievements in mathematics.

Based on the explanation, the research objectives are (1) accomplishment of POGIL learning toward critical thinking skill, (2) testing influences of logical-mathematical intelligence and musical intelligence toward mathematics critical thinking skill, (3) finding out description of mathematics critical thinking skill of students seen from logical-mathematical intelligence and musical intelligence.

METHOD

This mixed method research used sequential explanatory design. This quantitative research part used quasi experimental design. The research was begun by collecting and analyzing quantitative data before collecting and analyzing qualitative data on the second stage based on the first stage (Cresswell, 2016).

This research was conducted at Islamiyah VHS Sapugarut in August-September 2019 with X graders as the population in academic year 2019/2020. From six classes, it was selected one class as experimental group taught by POGIL model and another class as control group taught by PBL.

The subjects were selected by high logical-mathematical and low musical intelligence, low logical-mathematical intelligence and high musical intelligence, and high logical-mathematical and musical intelligences.

Based on multiple intelligence questionnaires, it was selected 5 students as informants to be interviewed. The selected criteria were high logical-mathematical intelligence ($skor > 21$), low logical-mathematical intelligence ($17 \leq skor \leq 21$) and low logical-mathematical intelligence ($skor < 17$) then high musical intelligence ($skor > 23$), moderate musical intelligence ($18 \leq skor \leq 23$) and low musical intelligence ($skor < 18$). The categorization of multiple intelligences was done by coding as seen on Table 1.

Table 1. The Subject Categories

Student Codes	Questionnaire Score		Criteria
	L I	M I	
E 2	24	17	High LI, Low MI
E 10	16	25	Low LI, High MI
E 13	27	24	High LI, High MI
E 15	16	23	Low LI, High MI
E 35	31	17	High LI, Low MI

LI=Logical-mathematical intelligence
MI= Musical Intelligence

The technique of collecting quantitative data was test of mathematics critical thinking skill. Meanwhile, the qualitative data collection techniques

consisted of questionnaire, interview, and documentation. The quantitative data was tested based on normality, homogeneity, variance, proportion, and influence test of logical mathematical intelligence and musical intelligence toward critical thinking skill. The qualitative data analysis was done by data reduction, display, and conclusion (Sugiyono, 2018:338).

FINDINGS AND DISCUSSION

Accomplishment of Process Oriented Guided Inquiry Learning Model

The validation result of the learning instruments could be seen on Table 2.

Table 2. Learning Instrument Validation Results

Learning Instrument	Scores	Categories
Syllabus	80%	Excellent
Lesson Plan	80%	Excellent
LKPD	80%	Excellent

Based on the table, the learning instrument validation showed the instrument was excellent. It showed that the learning instrument was reliable for the research. The validation results of the learning instruments could be seen on Table 3.

Table 3. Result of Research Instrument Validation

Research Instrument	Scores	Categories
Critical Thinking Skill Test	80%	Excellent
Interview Guideline	80%	Excellent
Multiple Intelligence Questionnaire	80%	Excellent

From the table, it could be concluded that the average of research instrument validation was 80%, categorized excellent. Thus, it could be used for the research.

In this research, there were two classes: X AKL 4 as control group and X AKL 3 as experimental group. The implemented model for control group was PBL while the experimental group was POGIL.

Before the classes were experimented, they were tested in terms of normality and homogeneity. The normality test was purposed to find out the obtained data whether it was normally distributed or not. Based on the normality test, it was obtained $sig = 0.435 > 0.005$ meaning that H_0 was accepted or the data of initial mathematics critical thinking skill of the students was from normal distribution population. Then, homogeneity test was conducted. It had purpose to find out the existence of variance difference between two samples. Based on the test, it was obtained $sig = 0.955 > 0.05$, and then H_0 was accepted. It meant the initial critical thinking skills were from same variances. Then, test of mathematics critical thinking skill average equality was conducted. The test used t-test to find out the similarity or equality of both groups' mathematics critical thinking skills. Based on the test, the t-test was done by using SPSS and it was obtained $sig = 0.668 > 0.05$, then H_0 was accepted and H_1 was denied. It meant there was no difference of the skill average of both groups. Then, the quantitative and qualitative data were analyzed.

The quantitative data analysis was done to find out accomplishment of POGIL model toward mathematics critical thinking skill. POGIL is said to be accomplished if the mathematics critical thinking skill met 4 criteria: (1) the average of mathematics critical thinking of the students surpassed actual accomplishment passing grade (AAPG) = 60; (2) mathematics critical thinking skill reached minimum accomplishment 75%; (3) the average of the students' skill taught by POGIL was better than those taught by PBL model; (4) proportion of the skill taught by POGIL was better than the students' mathematics critical thinking skill proportion taught by PBL.

The first criterion was average mathematics communication skill of students surpassing AAPG = 60. The score was determined by ($\bar{x}$+0.25 SD) in which $\bar{x}$ is average score of the class and SD is standard deviation (Sudjana, 2009). On the first criterion, the t-test used was one party t-test. It resulted to $t_{count} = 6{,}39$. Based on the t-table distribution, it was obtained $t_{table} = 1{,}69$ with significant level 0.05. Thus, $t_{count} \geq t_{table}$ then H_0 was denied. It meant the average score of mathematics critical thinking skill was higher than 60.

On the second criterion, it is mathematics critical thinking skill reaches the minimum passing

accomplishment grade 75%. To examine the first criteria by using accomplishment or one party proportion test which resulted to $z_{count} = 2.634$. Based on the Z-table distribution, it was obtained $z_{tabel} = 1,64$ with significant level 0.05. Thus, $z_{count} \geq z_{tabel}$ then H_o was denied. It meant the proportion of mathematics critical thinking skill was higher than 75% or it could be considered the mathematics critical thinking skill reached classical learning accomplishment higher than 75%.

On the third criterion, the mathematics critical thinking skill of students taught by POGIL was better than mathematics critical thinking skill of students taught by PBL. On the first criterion, the variance test resulted $t_{count} = 3,27$. Based on the t-table distribution, it was obtained $t_{tabel} = 1,667$ with significant level 0.05. Thus, $t_{hitung} \geq t_{tabel}$ then H_0 was denied. On the third criterion, the mathematics critical thinking skill of students taught by POGIL was better than mathematics critical thinking skill of students taught by PBL.

On the third criterion, the mathematics critical thinking skills of students taught by POGIL were better than mathematics critical thinking skill of students taught by PBL. On the fourth criterion, the proportional difference test esulted to $z_{count} = 3,62$. Based on the Z-table distribution, it was obtained $z_{tabel} = 1,64$ with significant level 0.05. Thus, it was $\geq z_{count}$ z_{tabel} then H_0 was denied. It meant the proportion of mathematics critical thinking skills of students taught by POGIL was better than mathematics critical thinking skill of students taught by PBL.

Based on those criteria, it could be known that the requirement of accomplishment learning had been met. Thus, it could be concluded that POGIL was able to improve mathematics critical thinking skill of the students.

Influences of Logical-mathematical intelligence and Musical intelligence to Critical Thinking Skill

Table 4. Output Results of Coefficient Regression Test Table

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B.	Std. Error	Beta		
(Constant)	43.32	8.29		5.23	.000
1 logic_music	1.311	.416	.481	3,15	.003

a. Dependent Variable: MCTS

Table 5. Output Results of ANOVA Regression Test Table

ANOVA[a]

Model	Sum of Squares	Df	Mean Squares	F	Sig.
Regression	566.702	1	566.702	9.957	,003[b]
1 Residual	1878.270	33	56.917		
Total	2444.971	34			

a. Dependent Variable: MCTS
b. Predictors: (Constant), logic_music

Table 6. Output Results of *Summery* Regression Test Table

Summary Model

Model	R	R Square	Adjusted R2 R Square	Std. Error of the Estimate
1	.481	.232	.209	7.544

a. Predictors: (Constant), logic_music

Based on output regression test result on Table 4, it was obtained score $a = 43,323$ and $b = 1,311$, thus, the regression equation $\hat{y} = 43,323 + 1,311x$ in which the independent variables were logical-mathematical intelligence and musical intelligence. Meanwhile, the dependent variable was mathematics critical thinking skills. The regression test output result on Table 5 obtained $sig = 0,03 < 5\%$. It meant the equation is linear so it could be concluded logical-mathematical intelligence and musical intelligence positively influenced mathematics critical thinking skill because the coefficient had positive sign (Sukestiyarno, 2013:46). The output of regression test on Table 6 shows score $R^2 = 0,232 = 23,2\%$. It shows that mathematics critical thinking skill (y) could be explained by logical-mathematical intelligence and musical intelligence (x) with 23.2%.

The regression test shows logical-mathematical intelligence and musical intelligence influenced critical thinking skill. It is consistent with Leonard and Nanda (2018: 196) that logical-mathematical intelligence emphasized questions solution by using logics which requires students to think and analyze the questions. Meanwhile, musical intelligence provides freedom for students to imagine and think creatively in broader manner, to think critically in deeper manner, and to be able to solve problems by rhythmic calculation.

Description of Critical Thinking Skill Seen from Logical-Mathematical Intelligence and Musical Intelligence

The qualitative analysis was conducted after critical thinking test and interview done by the researcher to selected subjects. Subjects with high logical-mathematical intelligence and low musical intelligence are represented by E2 and E35 subjects. Subjects low logical-mathematical intelligence and high musical intelligence are represented by E10 and E15 subjects. Subjects with high logical-mathematical intelligence and musical intelligence are represented by E13 and E35 subjects.

The analysis was done based on critical thinking skill test and the interview. The analysis of critical thinking skill was based on five indicators of critical thinking skill according to Facion - Angelo (in Seventika, 2018). They are (1) interpreting problems, (2) analyzing problem solutions, (3) implementing solutions, (4) evaluating solutions, and (5) concluding the results to the supporting facts.

Based on the findings, students with high logical-mathematical intelligence and low musical intelligence had excellent developing critical thinking skill. The students were able to interpret problems, implement the solution, evaluate solution, and conclude the result to the supporting facts. This student category had difficulty to analyze the solution.

In analyzing solution, students with high logical-mathematical intelligence and low musical intelligence had developed well because they could illustrate certain problems through a model although they had not been able to connect the obtained information by solving the concept because they did not write the problems into a variable.

In implementing solution, the students with high logical-mathematical intelligence and low musical-intelligence had developed well. The students could implement solution by using the obtained strategy to solve problems but there were students carelessly and unsystematic cooperating.

In evaluating solution, the students with high logical-mathematical intelligence and low musical-intelligence had developed well. They could recheck all stages they took. They could review all identified information and were able to verify the evidence of reference and supports.

In concluding result to supporting facts, students with high logical-mathematical intelligence and low musical intelligence could create correct conclusion. They could attach supportive evidence. They could explain logically through interview.

Students with low logical-mathematical intelligence but high musical intelligence were generally less capable in term of their mathematics critical thinking skill. They could interpret problems well. They had difficulties to conclude results to supporting facts. Students with moderate critical thinking skill could implement solution and evaluate it. They had difficulties to analyze problem solution because they had not been able to convert a problem into a variable form.

Students with low logical-mathematical intelligence but high musical intelligence could interpret problems well. They could determine what was known and unknown. They could map information based on problems but they had slight weaknesses.

In analyzing problem solution, they were not able to show their critical thinking skill. Typically, the students were able to find information concerning to solving concept and strategy as evidence of their difficulties to convert problems into a variable.

In implementing solution, low logical-mathematical intelligence but high musical intelligence were concluded to have developing mathematics critical thinking skill well. The students categorized as low critical thinking skill were less developed. They were not able to implement the solution and use the obtained strategy to solve problem and they did not work carefully and systematically because of their difficulties in operating a number.

In evaluating solution, low logical-mathematical intelligence but high musical intelligence were concluded to have developing mathematics critical thinking skill well. In another hand, students with low critical thinking skill, seen on all indicators, did not perform well because they did not recheck all solving stages and did not verify the referral and supporting evidence.

In concluding results to supporting facts, the students were not able to perform well. They could attach supportive evidence.but there were some of them not capable to do so. They could create conclusion correctly but there were some of them not capable to do so.

Students with high logical-mathematical intelligence and musical intelligence had well developed critical thinking skill. They were able to interpret well, implement solution, evaluate solution, and conclude the results to supporting facts.

In interpreting solution, the students with high logical-mathematical intelligence and musical-intelligence had developed critical thinking skill well They could map information based on problems. They could determine what was known and unknown.

In implementing solution, they had developed well in critical thinking. Students with high logical -mathematical intelligence and musical intelligence could implement solution and use the obtained strategy to solve problems. They worked carefully and systematically.

In evaluating solution, the students high logical-mathematical intelligence and low musical-intelligence could recheck all problem solving stages. They could verify the referral and supportive evidence.

In concluding result to supporting facts, they could create conclusion correctly. They could attach supportive evidence.

Based on the explanations, students with high logical-mathematical intelligence and musical intelligence could met all indicators of critical thinking skill. Those students could combine their right and left hemispheres. The right hemisphere thinking pattern style was more independent, random, comprehensive, intuitive, subjective, synthetic, and abstract. Meanwhile, the left hemisphere thinking patter seemed tend to be logic, rational, analytic, objective, systematic, and specific (Wigati, 2017; Ambarawati, 2014).

CONCLUSION

Based on the findings, the pattern of logical - mathematical intelligence described critical thinking skill level in implementing and evaluating mathematics solution. Higher logical-mathematical intelligence leads to higher critical thinking skill in implementing and evaluating mathematics solution and vice versa. However, dealing with musical intelligence, higher musical intelligence did not guarantee higher critical thinking skill in implementing and evaluating mathematics solutions.

Critical thinking skill of students on all types of logical-mathematical intelligence and musical intelligence could interpret problems well although they had difficulties in analyzing problem solution because they had difficulties in converting problems into variable forms.

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