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The Relevance of Mathematical Critical Thinking Skill with Numerical Intelligence and Learning Independence

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Abstract

Several studies show point out the ability of mathematical critical thinking of Indonesian students is still low, students often have difficulty dealing with situations that require problem-solving skills using Mathematics. Through a survey method, this research seeks to reveal the causal relationship between variables, namely whether the students' mathematical critical thinking skills of SMAN Serang Regency, West Java are influenced by numerical intelligence and are also influenced by students' learning independence. The research targets were class X students from: SMAN 1 Anyar, SMAN 1 Mancak and SMAN 1 Gunungsari which are in Serang Regency, West Java. A total of 88 students as respondents or research samples were selected using the *proportional cluster random sampling* technique. Data collection on students' mathematical critical thinking skills were used as an instrument for essay tests, data on students' numerical intelligence was used as a multiple choice test instrument, and learning independence was obtained by distributing a questionnaire. The results of the research show that there is an influence of numerical intelligence and learning independence partially and/or jointly on the students' mathematical critical thinking skills of SMAN Serang Regency. Students' mathematical critical thinking skills can be improved by optimizing internal and external factors withing themselves. Through fun Mathematics learning activities, prioritizing the scientific method approach in solving mathematical problems, as well as increasing awareness of learning independence by utilizing other sources of learning Mathematics besides from the teacher. In addition, seeking a positive attitude of students towards the importance of Mathematics learning to continue to be appropriately organized.

Keywords: Critical Thinking Skill, Mathematics, Numerical Intelligence, Learning Independence

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INTRODUCTION

Today's globalization era is marked by the implementation of free trade between countries, so that barriers between countries become invisible (borderless). In this context, only human resources who have competitiveness and qualified competence against change will be able to survive and to develop. The 21st century skills that are very important for students to be able to compete in the future are communication, collaboration, critical thinking, and creativity (4C) are emphasized through project-based learning, usually through interdisciplinary activities (Schatz, 2015).

However, several studies show that students' critical thinking skills are still low, with reference to the results of The Trends in International Mathematics and Science Study (TIMSS) indicating that until 2015 Indonesia was ranked lower (Asmarani and Musrikah, 2022). Moreover, in the field of Mathematics, the average score of PISA test for Indonesian students fluctuated. At PISA 2018, Indonesian students obtained an average score of 379. Furthermore, according to the OECD (the Organization for Economic Cooperation and Development), around 71% of students did not reach the minimum competency level in

Mathematics. This means that there are still many Indonesian students who have difficulty dealing with situations that require problem-solving skills using Mathematics (Wuryanto and Abduh, 2022).

Critical thinking is very important for students because it enables them to solve problems in difficult situations and have effective and accurate communication (Basri, at all, 2019). Critical thinking basically involves a set of skills, such as analyzing, arguing, synthesizing, evaluating and applying (Norman, Chang, and Prieto, 2017). Critical thinking has become an essential competency for people in the new information age and the global economy society (Mason, 2007 in Norman, Chang, and Prieto, 2017). Thus, critical thinking is defined as the ability to use acquired knowledge in a flexible and meaningful way, through understanding a problem or an issue, evaluating an evidence, considering many perspectives, and taking a position. Consequently, it is best understood from an individual's perspective through the acquisition of deep and meaningful understanding as well as critical investigation of content-specific abilities, skills, and dispositions. As a product, critical thinking may be best assessed through individual educational assignments, but it is a cognitive process that is complex and (only indirectly) accessible (Garrison, et al., 2001; Schrire, 2006 in Norman, Chang, and Prieto, 2017).

One area of knowledge that can shape and can improve students' skill to think critically is Mathematics, because Mathematics requires a strong reasoning base (Irawan, 2014; Jumaisyaroh, 2015; Suseno, 2019). Mathematics and critical thinking cannot be separated from each other, if the learning of Mathematics that is sought is meaningful. Therefore, teaching critical thinking in Mathematics class should be the goal of Mathematics educators (Jacob, 2012).

In Mathematics learning, scientific methods are taught in solving problems. Because humans are required to understand problems, to formulate problems, to dig up information, to analyze information, to make presumptions, to test presumptions and to draw conclusions carefully. Mathematics is a symbolic language whose main characteristic is the use of deductive reasoning but also not forgetting inductive reasoning (Kline, 2001:172). The objectives of teaching Mathematics in particular: 1) To prepare a person to be able to deal with the circumstances changing in life and in an ever-evolving world, through practice acting on the basis of thinking logically, rationally, critically, carefully, honestly, effectively and efficiently, 2) To prepare a person in order to be able to use Mathematics and a mathematical mindset in everyday life and in studying other sciences (Depdiknas, 2018).

Students' Mathematics learning outcomes can be seen when the learning objectives that have been set can be achieved by students and vice versa. Basically, students' Mathematics learning outcomes are influenced by several factors, including students' abilities, the intelligence of the students themselves and the teacher's teaching quality or the effectiveness of the teaching and learning process in achieving the teaching goals. Teaching and getting accustomed to students to always think and act mathematically, so that future expectations will be used in solving problems in their daily lives. Thinking is a dialectical process, meaning that during the thinking process, the mind holds questions and answers with the mind itself to put the relationships between knowledge appropriately (Sujanto, 2004). When humans have the ability to think, it is said that there are no humans who are not intelligent, intelligence comprises of 8 parts, namely linguistic intelligence, mathematical logical intelligence, visual spatial intelligence, musical intelligence, kinesthetic intelligence, numerical intelligence and natural intelligence (Gardner, 2007).

Numerical intelligence is an intelligence in using numbers and reasoning (logic) covering Mathematics, classifying and categorizing information, thinking with abstract concepts to find relationships between one thing and another (Irawan, 2016). Numerical ability can be interpreted as the ability to count, the ability to reason with numbers, the

ability to use or to manipulate number relations and to parse them logically (Zikriyah, 2018). Meanwhile, testing numerical intelligence can be conducted to test the accuracy, consistency, and accuracy of answering questions in the form of numbers (Sunarya, 2008). Hence, numerical intelligence includes the ability to count in addition, the ability to count in subtraction, the ability to count in multiplication, and the ability to count in division.

Besides students' intelligence, learning objectives will be successful if there is learning independence in students. Johson (in Waluyo, 2008:225) suggests that 5 (five) characters of independent people include 1) competence, 2) having courage to make decisions, 3) having initiative to solve problems, 4) self-confidence, and 5) responsibility. Students who have an independent character will take the initiative to solve problems with courage in making decisions. Learning independence is the students' behavior who have learning initiatives, are able to overcome learning problems with or without the help of others, are able to choose and to apply learning strategies, to utilize and to find relevant learning resources so that learning objectives can be achieved.

Learning independence for students in the process of learning Mathematics is very important, because of the demands of the curriculum so that students can deal with increasingly complex problems and reduce students' dependence on other people in everyday life. Independence is a positive mental attitude of an individual for the convenience of carrying out planning activities to achieve goals by positioning or conditioning her/himself so that she/he can evaluate her/himself and her/his environment (Suhendri, 2012) or not depend on other people including teachers (Fajriyah, 2019; Rustyani, 2019).

Learning independence is a person's tendency to be independent and to struggle in achieving success or choosing an activity that is oriented to the goal of success or failure. With independence, students have the initiative to add to their mathematical knowledge outside of the learning that has been conveyed by the teacher (Bungsu, et. al, 2019), students to discover how academic life is in line with everyday life (Jonhson, 2009). Because Mathematics learning resources are not only teacher-centered, but can be coming from the environment, social media, books, and so forth. Learning independence comes from within the individual and not from other people, so that the success in learning can be achieved. In this case, the role of students must be enhanced so that they actually become subjects in the teaching and learning process.

Considering the background and the focus of the research, the researchers took these research problems to find out how numerical intelligence influences the ability to think critically in Mathematics; the effect of learning independence on the ability to think critically in Mathematics; and the effect of numerical intelligence and learning independence altogether on the mathematical critical thinking skills of high school students in Serang District, West Java. The purpose of this research is to find out how numerical intelligence and learning independence influence the mathematical critical thinking skills of high school students in Serang District, West Java.

METHODS

The method used in this research was a survey method with a quantitative research approach. This type of survey research focused on disclosing causal relationships between variables. The survey method is a method of investigation conducted to obtain facts from existing phenomena and to seek factual information, to explore and to identify problems and to obtain justification for the situation. and ongoing practices (Nasir, 2005).

Using a survey method is that a research conducted on large and small populations, but the data studied is data from samples taken from this population, so that relative events,

distribution and relationships between sociological and psychological variables are found (Kerlinger, 2006). The relationship between those variables was is the relation between endogenous variable of mathematical critical thinking skill (Y), with exogenous variable namely numerical intelligence (X_1) and learning independence (X_2).

This research was conducted in the 2021/2022 academic year, odd semester in August - December 2021. The research targets were class X students from: SMAN 1 Anyar (355 students), SMAN 1 Mancak (222 students) and SMA Negeri 1 Gunungsari (123 students) which are in Serang Regency, West Java. A total of 88 students as respondents or research samples were selected using the *proportional cluster random sampling* technique.

Learning independence data was obtained by giving a questionnaire that had been prepared based on the indicators set to students. Data on students' numerical intelligence was used as an instrument in the form of 20 items multiple choice tests, and data on students' mathematical critical thinking skill was used as an instrument in the form of 5 items essay tests. All research data were obtained directly from the field (primary data sources).

Table 1. Research Instruments Outlines

Variable	Indicator	Total of Items
Numerical Intelligence	1. Understand operations (addition, subtraction, multiplication and division) and their properties, 2. Able to perform simple mathematical calculations, 3. Understand the relationship between numbers and the ability to perform numerical calculations,	20 items Multiple Choice Test
Learning Independence	1. Learning Initiative, 2. Diagnosing Learning Needs, 3. Setting Learning Goals/Targets, 4. Monitoring, Organizing and Controling Learning, 5. Seeing Difficulties as Challenges, 6. Seeking and Utilizing Relevant Sources, 7. Selecting and Implementing the Appropriate Learning Strategy, 8. Evaluating Learning Processes and Outcomes, 9. Self-Concept.	40 questionnaire items with 4 attitude scales (Frequently, Often, Seldom, and Rarely)
Mathematical Critical Thinking Skills	1. Focusing on questions, 2. Identifying assumptions, 3. Determining actions, Math problems on the subject: exponential equations; compound interest and population growth using exponential equations.	5 items Essay Test

The analysis used on the research data includes: descriptive analysis, requirement test analysis, and inferential analysis to reveal whether or not there is a relationship between exogenous variables and endogenous variables. The magnitude of the relationship between variables was obtained from data analysis using the calculation of the correlation coefficient and the value of the coefficient of determination. The calculation process was carried out through the *SPSS for Windows version 26* application on computer program.

RESULTS & DISCUSSION

Results

Descriptive Data

Table 2. Description of Statistical Data

No	Description	Numerical Intelligence	Learning Independence	Mathematical Critical Thinking Skills
1	Minimum	38	91	25
2	Maximum	100	148	100
3	Mean	72,44	117,17	60,91
4	Median	75,00	117,00	59,50
5	Mode	75	106	82
6	Std. Deviation	15,165	14,855	19,051

The description of numerical intelligence shows that the mean and median values are close, that is, 72.44 and 75.00. This indicates that the numerical intelligence data obtained in this research is quite representative. Respondents who get an average score or more ($x \geq \bar{x}$) are 46 people, and those who get a score below the average ($x < \bar{x}$) are 42 people. This shows that the numerical intelligence of students in SMA Negeri Serang tends to be good.

The description of the data shows that the average and median scores are almost the same, namely 117.17 and 117.00. This points out that the learning independence score data in this research is quite representative. The standard deviation score of 14.855 shows the difference in answers between respondents is considered as high. This shows that the learning independence of the respondents from the three schools is quite diverse.

Data on mathematical critical thinking skills obtained from respondents have an average of 60.91, with a standard deviation of 19.051, a median of 59.50, a minimum score of 25 and a maximum score of 100. From this description it can also be seen that between the mean and the median is almost the same, that is, 60.91 and 59.50. This means that the score data for mathematical critical thinking skills in this research is quite representative. The standard deviation score of 19.051 shows the difference in answers between respondents is considered as high. This shows that the mathematical critical thinking skills of the respondents are quite diverse.

Assumption Test

The results of the normality test for numerical intelligence, learning independence, and students' mathematical critical thinking skills can be seen at table below:

Tabel 3. Test Result of Normal Distribution Data

Nomor	Variable	One sample Kolmogorov-Smirnov Test (Asymp.sig. 2-tailed)
1	Numerical Intelligence	0,063
2	Learning Independence	0,192
3	Mathematical Critical Thinking Skills	0,057

It can be seen that the *Sig* value in the *Kolmogorov-Smirnov* method for all samples is greater than 0.05, so that H_0 is accepted, in other words that the data from all samples in the three research variables are normally distributed.

The results of the calculation of the linearity test of the regression line of the relationship between variable X_1 and variable Y, obtained the value of *Sig* line *deviation*

from Linearity = 0.513 for all samples more than 0.05, so H_0 is accepted, in other words that the regression line of the relationship between variable X_1 and variable Y is linear.

Similarly, testing the linearity of the regression line of the relationship between variable X_1 and variable Y, obtained a value of *Sig* line *deviation from Linearity* = 0.119 for all samples more than 0.05, so that H_0 is accepted, in other words that the regression line of the relationship between variable X_2 and variable Y is linear .

While testing the Multicollinearity of the data in this research was carried out by looking at the value of the *Variant Inflation Factor (VIF)*, the results of the calculation of the multicollinearity test obtained the following results:

Table 4. Recapitulation of Multicollinearity Test Results

Coefficients

Nomor	Variable	Tolerance	IF
1	Numerical Intelligence	0,944	1,059
2	Learning Independence	0,944	1,059
Dependent Variable: Mathematical Critical Thinking Skills			

From table 4 above, the value of *VIF* = 1.059 < 10 is obtained for all independent variables. Thus, it can be concluded that there is no multicollinearity between the independent variable of numerical intelligence (X_1) and learning independence (X_2).

Hypothesis Test

Table 5. Calculation Result of the Regression Line Equation of Variabel X_1 and X_2 on Variabel Y

Model	Variable	Unstandardized B	t	*Sig*
	Constant	-46,812	-3,792	0,000
X1	Numerical Intelligence	0,595	6,029	0,000
X2	Learning Independence	0,552	5,480	0,000
Dependent Variable (Y): Mathematical Critical Thinking Skills				

From the table 4 it can be seen that the value of ***Sig*** = 0.000 < 0.05 and t_{count} = 6.029, then H_0 is rejected which means that there is a significant influence of the numerical intelligence variable on the mathematical critical thinking skills of high school students in Serang Regency. Furthermore, the influence of learning independence variables on the mathematical critical thinking skills obtained a value of ***Sig*** = 0.000 < 0.05 and $\mathbf{t}_{count}$ = 5.480, meaning that there is a significant influence between learning independence and mathematical critical thinking skills.

The correlation coefficient value of numerical intelligence and learning independence jointly on the mathematical critical thinking skills is 0.711, and that correlation coefficient is significant. While the magnitude of the coefficient of determination is 0.505 indicating the magnitude of the contribution of numerical intelligence and learning independence jointly to mathematical critical thinking skills is 50.5%, and the remaining 49.5% is due to the influence of other factors that are not examined in this research.

The shows that the value of ***Sig*** = 0.000 < 0.05 and F_{count} = 43.444, then H_0 is rejected which means that the regression coefficient is significant. In other words, there is a

significant influence of numerical intelligence and learning independence altogether on the mathematical critical thinking skills of high school students in Serang District.

Discussion

The mathematical critical thinking skills have been shown to be significantly influenced by numerical intelligence, as evidenced by the value of *Sig* = 0.000 < 0.05 and the value of t_{count} = 6.029. This shows that the higher the level of a person's numerical intelligence, the higher the level of mathematical critical thinking skills or vice versa. In essence, a person's numerical intelligence cannot be increased because it is an innate factor, but a person's numerical intelligence can be maximized with lots of practice in thinking, calculating, and analyzing the numbers found in everyday life (Irawan, 2012).

This is supported by Schafersman (1991 in Kurniati, et. al, 2015) that critical thinking can be obtained by thinking correctly, through the flow of thinking using the scientific method. The flow of critical thinking through the use of similar scientific methods is explained by Karim & Normaya (2015) that there are four indicators of mathematical critical thinking skills: 1) Interpretation, understanding the problem raised by writing down questions that are known or asked correctly; 2) Analysis, identifying the relationship between statements and concepts given in the problem indicated by making a mathematical model and providing explanations correctly; 3) Evaluation, using the appropriate strategy in solving problems, complete and correct in making calculations; and 4), Inference, drawing conclusions appropriately according to the context of the problem.

These results are in line with Irawan (2014) that there is a significant influence between the mastery of mathematical concepts on mathematical critical thinking skills, meaning that the higher a person's mastery on mathematical concepts, the higher the level of mathematical critical thinking skills or vice versa.

The mathematical critical thinking skills is proven to be significantly influenced by the learning independence variable, this is evidenced by the value of *Sig* = 0.046 < 0.05 and the value of t_{count} = 5.480. There are two factors that affect students' mathematical critical thinking skills, namely factors from within the student (internal) and factors from outside the student (external). One of the internal factors is from learning independence. The independence is needed by students in dealing with tasks that are independent, so that students are able to solve problems faced by themselves without having to expect a help from others. Mathematical critical thinking is a skill and disposition combined with prior knowledge, mathematical reasoning skills, and cognitive strategies to generalize, to prove, to evaluate mathematical situations reflectively (Alvira and Surya, 2021).

Hence, learning independence can be referred to as a freedom of learning that a person does according to her/his own abilities without the influence of other people. Learning independence is closely related to an individual's belief about her/his ability to organize and to complete a task needed to achieve certain results. The low mastery of teachers on the subject matter she/he teaches, as well as the ability to choose an inappropriate teaching methodology is strongly suspected as the low achievement of students' learning outcomes that are happening at this time (Philip Suprastowa, 2002:35). The low ability of teachers to think critically and creatively is considered as one of the reasons for the low ability of critical thinking and creative learners in Indonesia (Kurniati, et al., 2015). As students improve their critical thinking skills, instructors should witness students recognizing and/or appreciating ideas not previously considered (Norman, Chang, & Prieto, 2017).

Efforts that continue to be driven by teachers and the environment are able to develop positive and consistent attitudes that are real in exploring Mathematics lessons (Suseno, 2019). Critical thinking development may be impeded in a learning environment where the

student may feel their differing opinions are not respected. For example, students with shared cultural experiences and worldviews working alone may arrive at a conclusion too quickly without reviewing other perspectives. The opportunity for a broad discussion that is inclusive to students with different experiences and different cultures may present different perspectives. Inside and outside of the classroom and the business world, like-mindedness may create rigidity and decrease critical thinking. These dialogue exchanges could strengthen content by enhancing comprehension and offer opportunities to develop and exchange views and ideas, thereby promoting critical thinking skills (Norman, Chang, & Prieto, 2017).

Given the curriculum that drives programs, it is important to deliberately have some type of policy or guidance to establish an environment that supports discussions related to culturally sensitive issues (Norman, 2012). These indicated that the critical thinking skills of prospective teachers and students were still in a low category. Enable mathematics teacher educators to design curricula, courses, and/or teaching practices that could improve the critical thinking skills of prospective mathematics teachers, which in the long term could help Indonesian students to have better critical thinking skills (Basri., et al, 2019). The mathematical critical thinking skill is closely related to the process of solving real problems using mathematical concepts. A student with higher learning independence will face assignments and tests with more confidence and self-confidence, even though the problems encountered are difficult, students will feel confident that they can solve them well, so that students' learning independence will affect their mathematical critical thinking skills.

The improve mathematical critical thinking skills include applying a learning method or model which can improve students' critical thinking skills especially in the evaluation, analysis and self-regulation sub-skills and developing an instrument to measure students' critical thinking skills because so far the measurement of mathematical thinking skills using content that does notninvolve specific subject matter expertise (Basri, et. al, 2019).

Teachers must realize that students can collaborate and be confident in answering, are able to determine and to consider an action that must be taken in solving problems and the steps used are also more orderly and precise, more analytical in working on problems so that they can solve problems given in questions (Muhtadi, Supratman, and Hermanto, 2018).

CONCLUSION

The mathematical critical thinking skills are directly influenced by numerical intelligence and learning independence. Students' mathematical critical thinking skills can be optimized by encouraging mathematics learning activities that are able to invite students to continue learning regularly by prioritizing the scientific method approach in solving mathematical problems. In addition to optimizing students' internal factors, including increasing numerical intelligence and also increasing awareness of independent learning by utilizing other sources of learning Mathematics besides the teacher. In addition to seeking a positive attitude of students towards the importance of Mathematics learning to continue to be well organized. Because mental aspects that are not handled properly can be the cause of the emergence of certain patterns of thinking in students which undermine the building of positive character that students have. Therefore, it is necessary to encourage Mathematics teachers to design curricula, and/or to increase teaching practices that can improve mathematical critical thinking skills, which in the long term can help students to have better critical thinking skills. As students develop critical thinking skills, teachers

must be able to actually witness students recognizing and/or appreciating ideas that were not previously considered. Then give appreciation for any achievement even though it is too small, but this will be able to maintain the mental aspects of students' critical thinking.

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