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Analysis of Students' Critical Thinking Skills Based on Prior Knowledge Mathematics

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Abstract: The development of critical thinking skills has emerged as a global concern in a variety of fields, including education. The purpose of this study was to share light on the connection between one's prior knowledge and the mathematical critical thinking skills via quantitative approach. Data was collected through the use of mathematical instruments, mathematical critical thinking tests, and daily test data for the prerequisite material based on the average student's performance. High school students in the eleventh grade constituted the study's population. The finding of the study indicated that there is positive connection between mathematical background knowledge and critical thinking abilities in that subject area. The study further indicated that the initial knowledge of the leaners needed to be revised extensively in order to be successful in the subsequent new concept. However, the researchers discovered that the number of students who fell into the high and medium categories of critical thinking skills were lower compared to the number of students who fell into the second category when it came to their initial mathematical abilities. Thus, there has been a rise in the proportion of students who scored poorly on tests of their ability to engage in critical thinking. It is recommended that better teaching and learning strategies should be incorporated to improve prior knowledge.

Keywords: Critical thinking skill, higher-order thinking skill, prior knowledge mathematics

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1. Introduction

Critical thinking skill has become a worldwide issue in varied fields, moreover education (Abalı Öztürk, 2022; Ilkorucu et al., 2022; Maryuningsih et al., 2020; Purwanto et al., 2022) using social media (Sel, 2022) global citizenship (Kaya, 2022) interpersonal relationships (Jonaskova & Predanocyova, n.d.) journalists profession (Poplavska et al., 2022) writing skill (Erkek, 2022; Moonma & Kaweera, 2022) reading abilities (Hazaymeh & Alomery, 2021) using technology (Hamdani et al., 2022; Loh, 2020), etc. Critical thinking skills are very urgent for everyone today related to 21st century life skills competencies.

According to Kuloğlu (2022) pertaining to 21st-century skills, (Fletcher & Dumford, 2021) teachers have a responsibility to guide and encourage production readiness, curiosity, problem-solving skills, and critical thinking in their students. Thorndahl & Stentoft (2020) emphasized that nowadays critical thinking is at the top of the agenda (Fikriyatii et al., 2022; Maison et al., 2022) and very important and increasingly needed (Ristanto et al., 2022; Suparman, 2022). Facione (2011) confirms that critical thinking skill of our thinking is vital to our quality of life. Furthermore, lifelong encounters with complex challenges need the development of critical thinking abilities (Demirel et al., 2017; Rachmantika & Wardono, 2019; Zukhairina et al., 2020).

Critical thinking is an activity that emphasizes decisions about what to believe or reflective thought and deductive reasoning. Critical thinking helps students gain a deeper understanding of the presented information (Darmaji et al., 2020; Thorndahl & Stentoft, 2020). Critical thinking encourages the desire to expand one's knowledge and perspective (Elmouhtarim, 2018). In order for an individual to engage in effective critical thinking, they need to be able to assess and evaluate the quality, usefulness, and sufficiency of intellectual products, all of which correspond to particular cognitive skills and traits (Evans, 2020).

Scriven, M. & Paul (2005) emphasized critical thinking is not a talent that is innate to humans, nor is it something that can develop on its own; rather, it is a skill that needs to be learned. Humans are not born with the ability to think critically, nor can they develop this ability naturally. Critical thinking, like other skills, can be taught, learned, and developed through daily practice and application. Similar to other skills, critical thinking can be taught (Jackson, 2000). Kanmaz (2022) describe teaching critical thinking requires careful planning and coordination. In this regard, coordination between educators, critical thinkers, and administrators is also crucial. Ennis (2013), that the best way to teach critical thinking is to combine it with another subject, rather than as a separate course. Participation in research processes is one of the most effective ways to develop critical thinking, which is why research activities are essential to the development of critical thinking (Mataniari et al., 2020)

Critical reasoning is widely recognized as a crucial educational outcome (Bayram et al., 2019; Zimeri, 2016) however, teaching critical thinking is not a simple task (Fukuzawa & DeBraga, 2019). It is difficult for teachers to develop students' critical thinking skills if the teachers themselves do not have a strong understanding of critical thinking and how to encourage it in the classroom (Jatmiko et al., 2018; Suwandi & Istiyono, 2017). Minister of Research Technology and Higher Education Republic of Indonesia (2015) recommends that in order to develop critical thinking, teachers should not only learn how to think critically, but also help their students do so, but also incorporate critical thinking activities into the learning environment. Mathematics is one of the fields where critical thinking skills can be utilized effectively (Arison & Aybek, 2021).

Many authors (Kuş & Çakıroğlu, 2020; Munawaroh et al., 2018; Ridwan et al., 2022; Walters et al., 2018) described Mathematics can help improve person's ability to think critically. Analyzing different points of view is a skill required for critical thinking (Demir, 2022), achieving one's conclusions through the use of inductive or deductive reasoning (Upmeier Zu Belzen et al., 2021; Zulkipli et al., 2020), assessing or evaluating (Devika & Soumya, 2016) , and making decisions (Roberto Florez et al., 2022) or solving problems (Sholihah & Lastariwati, 2020). In a similar vein, the study of mathematics can help students develop their critical thinking skills (Nurhasanah et al., 2018). In the context of learning mathematics, some examples of activities that can help train critical thinking skills in the classroom include proving, comparing, analyzing, making contradictions, inducing, generalizing, sorting, classifying, evaluating, linking, and creating patterns and problems (Men et al., 2020).

Contrary to the importance of critical thinking, a number of studies have found that critical thinking is less developed among students in certain nations (Susetyarini & Fauzi, 2020). Studies from Baguma et al. (2019); Mustofa & Yuwana (2016); and Lambert et al. (2021) reported that students are desperate to think critically.

There are several reasons for having poor thinking skills, including students; learning models that are less active (Lestari et al., 2021), disliked math topics (Enikanolaye, 2021), prior knowledge mathematics is lacking (Lee et al., 2022). Of all the existing findings, the authors are interested in analyzing critical thinking skills from prior knowledge mathematics.

Prior knowledge is necessary but not sufficient for critical thought on a particular subject. Prior content knowledge has a significant impact on what is comprehended, remembered, and learned (McCarthy & McNamara, 2021). Prior studies have demonstrated students' prior knowledge (Siegler, 1988) influence the performance of problem-solving (Lee et al., 2022). Diverse fields of study have reported that students' prior knowledge has a significant impact on their ability to comprehend contemporary learning materials (Zakariya et al., 2020).

2. Methodology

This research was conducted at a high school in Majalengka Regency, West Java, Indonesia. The sample consisted of thirty-three eleventh-grade students selected using the method of convenience. The authors assumed that eleventh graders have adequate prior knowledge to continue studying mathematics at a higher level. Also, they are required to have adequate and strong higher-order thinking skills, particularly critical thinking. This survey study used correlation techniques to collect data from an initial knowledge examination and a test of critical thinking skills in the form of an essay. Following this, the data collected was analyzed utilizing Pearson Correlation to determine if there was a connection between prior knowledge skills as independent variable and critical thinking abilities as dependent variable. The validity and reliability of the data collection instrument was vigorously examined. This was done through experts view on the content of the instrument and a pilot study was done of similar grade characteristics. According to the findings of the validity study, every item on the tests of candidates' prior knowledge and critical thinking can be relied upon to accurately reflect their abilities.

Based on prior information, the researchers were able to describe the level of the student's critical thinking when solving arithmetic problems. The researchers also described the level of student performance in solving challenges using critical thinking as problems.

This study's sample included thirty-three senior high schools in the West Java region. The data for the study consisted of test questions on students' critical thinking skills and their daily test results, which provided information on their preliminary abilities. The test results were divided into groups of high, medium, and low skills, and two individuals are selected from each group. In this study, two students from the highest category, two students from the medium category, and two students from the lowest category served as subjects, and the level of performance was evaluated based on their critical thinking skills at solving predetermined arithmetic problems.

The examination comprised mathematical questions. The algebraic domain comprised seven description questions based on the material provided to pupils. Each question served as criteria or performance indicator regarding their critical thinking abilities. The goal of completing those questions were to guarantee that students could successfully complete questions of the same type. In addition, those outcomes were compared to daily examination questions on defined algebraic domain subject.

Student responses were analyzed using sheet-based assessments of critical thinking indicators, which were then classified into performance levels based on assessment guidelines for the level of performance attained. The scoring of student work on test questions was then adjusted based on the achievement of indicators. After grading student responses to test, questions administered.

3. Results and Discussion

3.1 Result

Students were assessed on prior knowledge mathematics and critical thinking skills for data gathering purpose. Table1 presents score distribution of prior knowledge and critical thinking skills.

Table 1. The distribution of scores in relation to the two variables

Prior Knowledge Mathematics		Creative Thinking Skill		Category
F	%	F	%	
6	18%	14	42	Low
13	39	10	30	Medium
14	42	9	27	High

From Table 1, it can be seen that students experience decrease in the number of high and medium categories. However, the low category experience an increase in critical thinking skills. This indicates that critical thinking skills require strong prior mathematical knowledge. There are 14 students in the high category for initial mathematical abilities and category in critical thinking skills are 9 students. That is, not only sufficient high initial mathematical ability to guarantee students have high critical thinking skills.

The research hypothesis that there is a relationship between student critical thinking skill and prior knowledge mathematics was tested. The correlation analysis of the hypothesis is presented in Table 2.

Table 2. Correlation analysis results

Variable	Sig. (2-tailed)	Pearson Correlation
critical thinking skill		,612**
prior knowledge mathematics	,000	

The correlation coefficient between critical thinking skills and prior mathematical knowledge is 0.612, which indicates that there is a positive relationship between the two variable. The critical thinking skills (X1) and prior mathematics knowledge (Y) relates to each other positively as coefficient of 0.6612 shows a strong association.

3.2 Discussion

The foundational mathematical understanding and skills that students possess can be applied toward comprehending and finding solutions to problems in later mathematical concepts. Students are expected to have acquired these skills and competencies either during the prior level of education or during the prior discussion topic pertaining to mathematics. Students who begin a course with high (adequate) level of prior knowledge will have no trouble solving problems involving higher mathematical concepts, which will allow them to finish the course with the mathematical critical thinking skills that are expected of them and make it simpler for them to learn subsequent subject matter.

Constructivist learning hinges on the prior experience of the learners and this finding supports the same view. The correlation indicates that effort should made in class to ensure that new mathematical concepts should have some associations with learners' experiences. The correlation coefficient infers that there is a positive and fairly robust relationship between students' prior mathematical knowledge and the ability to think critically about mathematics.

In the initial process of learning mathematics, it is necessary for the teacher to investigate and refresh the initial knowledge possessed by each student. This is especially important regards to concepts that are prerequisite material for the mathematics material that will be studied. This is usually done through a pre-test, which shows the level of prior knowledge the students possess towards the new mathematical concept.

Following Table 1, students who enter school with low level of mathematical knowledge demonstrate low levels of critical thinking skills. Skills at the intermediate and advanced levels are commensurate with early mathematical aptitude. This shows that children have variety of cognitive abilities. Students' responses to new challenges require creative thought in order to provide the needed solution. In the interpretation phase of study, students were required to comprehend questions related to problems. Fig 1. represents one questions on critical thinking skill.

2.Agar garis $y=-10x+4y$ menyinggung parabola $y=px^2+2x-2y$ maka konstanta $p=-18$. Periksa kebenaran solusi tersebut!	Translate 2. So that the line $y=-10x+4y$ touches the parabola $y=px2+2x-2y$, the constant $p=-18$. Check the correctness of the solution!

Fig 1. Question of Critical thinking Skill

Fig 2. shows a question which requires students to think critically before obtaining the solution. Students are required to make conjecture inductively and deductively, and evaluate decisions; decision-making by considering sufficient evidence to support the argument. This phase demands students to comprehend the situation and think in a variety of ways. It tries to compare answers to a question for a test of students' critical thinking skills between high, medium, and low initial mathematical abilities.

Some students in the lowest group did not understand the issue or lacked clarity regarding to the question. This indicates that students did not comprehend the questions in context. Some students appeared to comprehend the issue adequately. This is shown in the Fig2 of students with low prior knowledge.

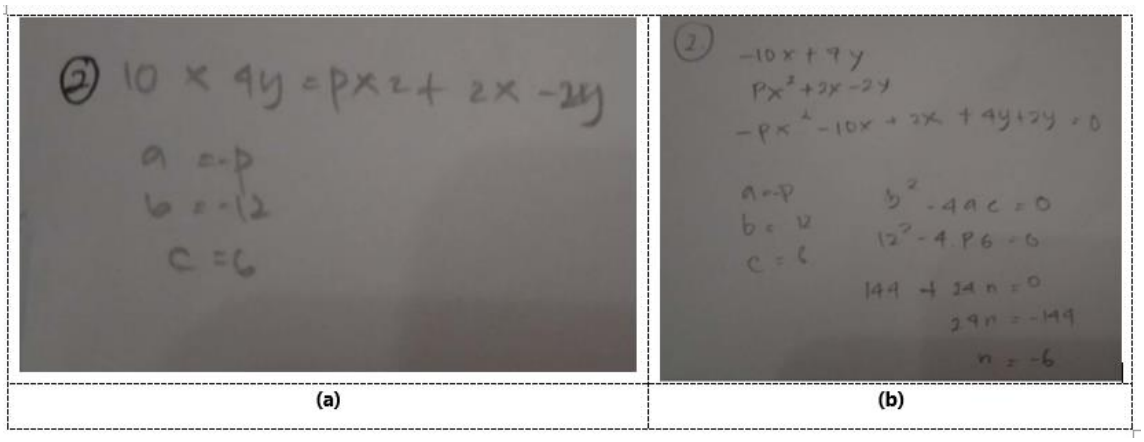

Fig. 2 – (a) and (b) Answers of students with low prior knowledge

According to Fig 2. (a) and (b) both show difficulty understanding the problem and the demand of question. The students did not know the proper procedure to be used to solve the problem. These students have prior mathematical knowledge with low critical thinking skills.

Children with average critical thinking skills are able to perform or write known mathematical tasks with errors and inaccuracies, however have good prior mathematical knowledge. Overall, children in this middle category are quite adept at answering the following types of questions:

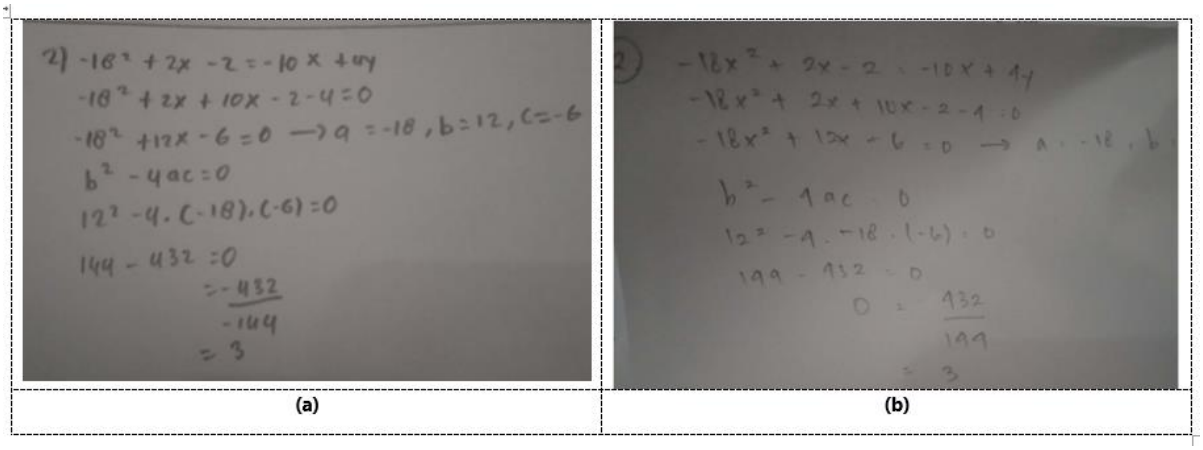

Fig. 3 – (a) and (b) Answers of students with middle prior knowledge

From Fig 3. (a) and (b) both show an attempt to solve a given problem, but both did not use the correct strategy. These are who have early mathematical abilities in the medium category but have low critical thinking skills

At this stage of critical thinking, it can be said that students in the highest category have a solid grasp of the questions. In addition, student can clearly record what is written on question and able to organize problem solving appropriately based on the following problem solving categories:

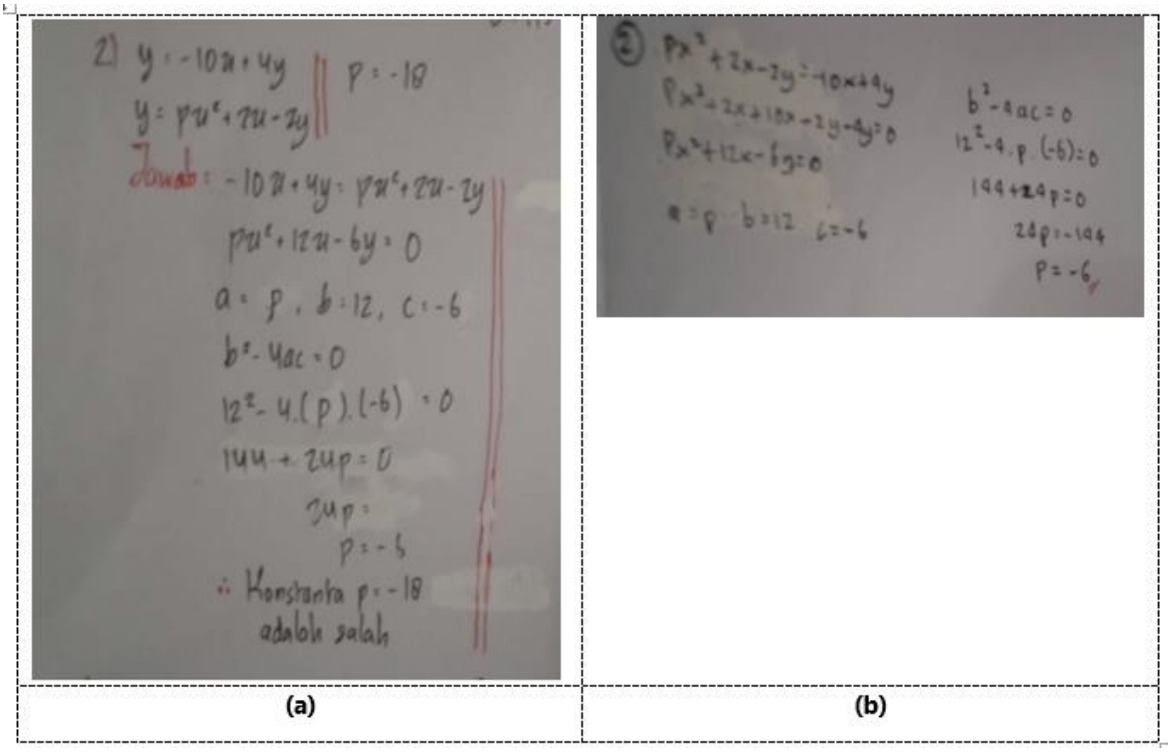

Fig. 4 – (a) and (b) Answers of students with high prior knowledge

Fig 4 (a) shows that these students can also solve the questions correctly. These students have early mathematical abilities and critical thinking skills in the high category. Furthermore, Fig 4 (b) shows that the student have shown effort to solve the given problem but have not used the right approach. These students have high initial mathematical abilities but medium category critical thinking skills.

From the findings of this study, the authors argue that early mathematical abilities have an influence on higher order thinking skills. However, these variables are not enough to have good critical thinking skills. There other factors that affect critical thinking skills and must be investigated.

4. Conclusion

Following the analysis can conclude that prior knowledge of math has a big effect on how well students do on tests of critical thinking skills. This can be inferred from the detailed discussion and analysis presented earlier. This demonstrates that the achievement of mathematical critical thinking skills is directly proportional to the level of initial knowledge possessed by the students. It is possible to draw a conclusion that the material that serves as initial knowledge and is considered prerequisite to be thoroughly studied in order to make a significant contribution to the success of the learning process.

However, the researchers found a decrease in the number of students in the high and medium categories of critical thinking skills compared to the number of students in the second category on initial mathematical abilities. That is, there is an increase in the number of students in the low category on critical thinking skills. It

is suggested that all stakeholder of education should take interest to ensure that teachers/instructors consider prior knowledge in teaching a new mathematical concepts.

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