Edukasia: Jurnal Penelitian Pendidikan Islam
https://journal.iainkudus.ac.id/index.php/Edukasia/index
P-ISSN: 1907-7254; E-ISSN: 2502-3039
Vol. 19 No. 1 Tahun 2024 | 99 – 114
DOI: 10.21043/edukasia.v19i1.19884

Critical Thinking, Literacy, and Numeracy as Factors in STEM: Madrasah Student Learning

Kuswanto[1], Zaenal Abidin[2], Rayvin D. Pestano[3], Muhammad Ikhlas[4]

Institut Islam Al Mujaddid Sabak, Jambi, Indonesia[1,2]
Central Luzon State University, Munoz, Philippines[3]
Universitas Negeri Medan, Indonesia[4]

kuswanto.edu@gmail.com[1]/Corresponding author
zaabiangsui@gmail.com[2]
rayvin.pestano@clsu.edu.ph[3]
m.ikhas@gmail.com[4]

Abstract

In the era of massive information sources, the ability of the young generation to have critical thinking, literacy, and numeracy skills is needed. These three variables are the focus of this study: how are students' abilities in critical thinking, literacy, and numeracy using STEM-based learning? To answer this problem, the researchers employed mixed research with an explanatory sequential design. The researchers used quantitative analysis and then utilized qualitative. The findings of this study revealed that STEM exerted a good influence on student learning. The findings of this study also stated that the ability of students to think critically was in a good category (n=76,55), literacy was in a good category (n=3,58), and numeracy was in a neutral category (n=58,57). In addition, the researchers uncovered that STEM is an alternative to teaching science and produces critical thinking, literacy, and numeracy skills.

Keywords: STEM, critical thinking, literacy, numeracy.

A. Introduction

Critical thinking skills are basic skills that students must have in the 21st century (Dilekçi & Karatay, 2023; Kennedy & Sundberg, 2020). Students should understand how to think critically because by thinking critically, they can more easily face the challenges of the new world. The advantage is that if students can think critically, they can understand information faster. The ability to think critically is owned by active students (Chukwunemerem, 2023; Pischetola & Martins, 2024). This ability is related to other abilities, such as scientific communication, self-confidence, and student motivation. However, most students' critical thinking skills are still at the intermediate level.

Critical thinking skills are of concern to science researchers (Anggraeni et al., 2023). In the previous research, it was found that the average score of students in the category of critical thinking skills was low (Mutakinati, Anwari & Kumano, 2018; Fuad et al., 2017). This indicates that the critical thinking skills of students in Indonesia remain low. In fact, this capability has become the main key in policy making. Therefore, research on this ability still needs to be done.

Critical thinking skills are influenced by several factors. These factors can be in the form of students' internal conditions, such as anxiety about mathematics and learning styles (Schulze & Bosman, 2018; Gurefe & Bakalim, 2018). Critical thinking skills are also influenced by the gender of students (Kurniawan, Darmaji, et al., 2023; Kurniawan, Wirayuda, et al., 2023; Nasution et al., 2023; Saleh et al., 2023). Nevertheless, this ability is also not influenced by majors, such as science, social science, and language (Bedford et al., 2019). Another factor that affects critical thinking skills is the learning model used by the teacher (Aston, 2023).

Critical thinking skills can be improved by using HOTS questions to improve and increase mastery of physics concepts (Wenno, Jamaludin, & Batlolona, 2021; Isnaeni et al., 2021). Learning by using questions (HOTS) can train students' critical thinking skills. The use of HOTS-based learning methods has the aim of increasing critical thinking power in receiving all information. HOTS questions emphasize information analysis, concept evaluation, and the creation of ideas or models of a science. To understand the reasoning of HOTS questions, good student literacy is thus required (Widana, 2020).

Literacy is the ability to process and understand information during the reading and writing process (Maslihah, Waluya & Suyitno, 2020; Damaianti, Abidin & Rahma, 2020). In its development, the definition of literacy always evolves according to the

challenges of the times. In the past, literacy was defined as the ability to read and write (Tambunan & Naibaho, 2019; Kartini & Sumarmin, 2020). Currently, the term literacy has begun to be used in a broader sense (Kahn & Kellner, 2023). It has penetrated cultural practices related to social and political issues.

Meanwhile, numeracy is the ability and knowledge to use some numbers and symbols related to basic mathematics to solve everyday problems and analyze them in the form of graphs, tables, and diagrams (Abbas & Bito, 2024; Nuryami, 2024; Rahmawati et al., 2023). Numeracy problems often occur in social mathematics cases (Coffey & Sharpe, 2023; Thompson et al., 2023). Numeration is a person's ability to use numbers to solve practical problems in everyday life (Nahdi et al., 2020; Kieren, 2020). To improve this ability, the researchers tried to use STEM. STEM is an approach used to improve students' abilities in science, technology, engineering, and mathematics (Abbah, 2017). The STEM approach has been widely applied in various schools in Indonesia.

This research is supported by relevant previous research. The variables of this research are based on the urgency of students' critical thinking skills in madrasah schools. In addition, madrasah schools are also able to contribute to literacy and numeracy levels. The researchers employed STEM to be a place to grow skills in literacy, numeracy, and critical thinking. Therefore, this study focuses on how students' abilities in critical thinking, literacy, and numeracy are.

B. Method

The researchers focused on the problem: how are critical thinking skills, literacy, and numeracy and how to teach STEM to madrasah students? The researchers implemented STEM for dynamic fluid learning processes. To unravel the focus and formulation of the research problem, the researchers utilized a mixed method with explanatory sequential design. The sample in this study amounted to 86 students. The sample of this study used random sampling from four classes taught using STEM. The analysis used in this study follows the following figure.

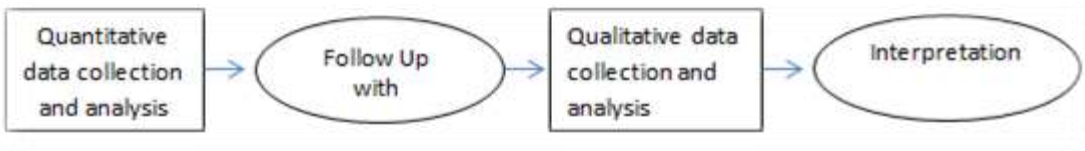

Figure 1. Analysis of the study

In Figure 1, it is depicted that the researchers took quantitative data and analyzed it, and then the researchers took qualitative data. The quantitative data were the descriptive data on the critical thinking, literacy, and numeracy of students. The quantitative data were then analyzed by descriptive statistics, mean, and frequency. This research instrument had been validated, and its reliability had been measured and was ready to be used for this research. The following are categories of critical thinking skills, literacy, and numeracy.

Table 1 Category of critical thinking, literacy, and numeracy

Category	Range score		
	Critical thinking	Literacy	Numeracy
Very poor	0 – 20	1.00 – 1.80	0 – 20
Poor	21 – 40	1.81 – 2.60	21 – 40
Neutral	41 – 60	2.61 – 3.40	41 – 60
Good	61 – 80	3.41 – 4.20	61 – 80
Very good	81-100	4.21-5.00	81 - 100

Table 1 details that the researchers divided each student's ability into five categories, namely very poor, poor, neutral, good, and very good. Quantitative data provides general information, and then the researchers continued to take qualitative data in the form of interviews and student learning processes using STEM. The analysis used was descriptive. At the end of the analysis, the researchers used qualitative data, which could provide an overview of quantitative data. These data were then interpreted to form a conclusion.

C. Results and Discussion

Educational Movement in the Reform Era

Improving students' abilities must be based on a good learning experience. Students who have done good learning have good abilities, too. The researchers found

that the ability of students at Madrasah A had good critical thinking skills. This can be seen in the table of critical thinking skills below.

Table 2 Critical thinking skills

No	Category	Range score	Frequency		Percentage		Mean
			Male	Female	Male	Female	
1	Very poor	0 – 20	2	1	2.33%	1.16%	76.55
2	Poor	21 – 40	2	3	2.33%	3.49%	
3	Neutral	41 – 60	10	8	11.63%	9.30%	
4	Good	61 – 80	25	23	29.07%	26.74%	
5	Very good	81-100	8	4	9.30%	4.65%	

Table 2 reveals that students' critical thinking skills tended to be categorized as good (mean = 76.55). In addition, it can be seen from the number of students who were categorized as very good, as many as 12, with the percentage of males at 9.30% and females at 4.65%. The good category had as many as 48 students, with the percentage of males at 29.07% and females at 26.74%. There were 18 students in the neutral category, with the percentage of males 11.63% and females 9.30%. In the poor category, there were five students, with a percentage of 2.33% male and 3.49% female. In the last category, students were categorized as very poor, as many as 3, with 2.33% male and 1.16% female. Furthermore, the researchers describe the data on students' literacy abilities as follows.

Table 3 Categories of students' literacy skills

No	Category	Range score	Frequency		Percentage		Mean
			Male	Female	Male	Female	
1	Very poor	1.00 – 1.80	0	0	0.00%	0.00%	3.58
2	Poor	1.81 – 2.60	2	1	2.33%	1.16%	
3	Neutral	2.61 – 3.40	10	13	11.63%	15.12%	
4	Good	3.41 – 4.20	28	19	32.56%	22.09%	
5	Very good	4.21 - 5.00	7	6	8.14%	6.98%	

The literacy skills of students were generally classified as "good" (mean = 3.58), as illustrated in Table 3. Furthermore, the number of students who were classified as "very good" was 13, with a male-female ratio of 8.14% and 6.98%. As many as 47 students were in the good category, with a 32.56% male and 22.09% female ratio. The neutral category contained 23 students, with a male percentage of 11.63% and a female percentage of 15.12%. There were three students in the poor category, with a male percentage of 2.33% and a female percentage of 1.16%. As many as 0 students were classified as very poor in the final category. Additionally, the researchers provide the following description of the numeracy skill data of the students.

Table 4 Categories of students' numeracy abilities

No	Category	Range score	Frequency		Percent		Mean
			Male	Female	Male	Female	
1	Very poor	0 – 20	1	4	1.16%	4.65%	58.57
2	Poor	21 – 40	2	7	2.33%	8.14%	
3	Neutral	41 – 60	20	13	23.26%	15.12%	
4	Good	61 – 80	18	9	20.93%	10.47%	
5	Very good	81 - 100	6	6	6.98%	6.98%	

As demonstrated in Table 4, the numeracy abilities of students were generally classified as neutral (mean = 58.57). In addition, the number of students who were classified as "very good" was 12, with a male-female ratio of 6.98%. The good category contained a maximum of 27 individuals, with a male percentage of 20.93% and a female percentage of 10.47%. The neutral category contained 33 students, with a male percentage of 23.26% and a female percentage of 15.12%. Nine students were enrolled in the poor category, with a male percentage of 2.33% and a female percentage of 8.14%. Five students were classified as "very poor" in the final category, with a male percentage of 1.16% and a female percentage of 4.65%.

The researchers then analyzed the findings into parts that the researchers could conclude. Furthermore, the researchers present it in the form of Figure 2. It is obtained from the findings carried out using quantitative data. From the findings of the researchers, it can be concluded that the ability of students to use STEM was quite good. To see the order of the abilities of these three variables, see the following figure.

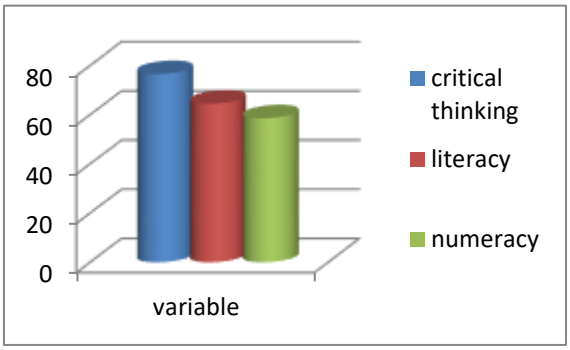

Figure. Comparative of critical thinking, literacy, and numeracy

It was found that the lowest student's ability was numeracy, with a value of 58.57, while for literacy, it was 3.58 and was equivalent to 64.5, and the highest position was critical thinking, which was 76.55. Hence, from the figure, it has been illustrated that STEM greatly affects critical thinking.

Afterward, the researchers explained how STEM was taught to madrasah students. STEM (Science, Technology, Engineering and Mathematics) learning was chosen as one of the alternatives (Lhéritier et al., 2019; Butler, 2018). The lessons at the madrasah received much good input from the science teacher. Especially in choosing a theme, the teacher suggested increasing the topic of discussion. First, the researchers took the topic of fluid. This was taken by the researchers because the level of complexity is good enough to integrate science and technology (Romero., Lepage & Lille, 2017), as well as engineering and mathematics. The researchers made a tool that can explain concepts well. After demonstrating in front of the class using the tool, the researchers tried to periodically interview students about how they thought STEM-based learning was.

Fundamentally, STEM education provides educators with the opportunity to show students that STEM concepts, principles, and techniques are used in an integrated manner in the development of products, processes, and systems used in their daily lives (Juškevičienė., Dagienė & Dolgopolovas, 2021; Violante & Vezzetti, 2017). This is also reinforced by the interview findings that "...yes, I see that the lesson this time is different. Quite complicated but applicable." Students admitted that learning was complicated but could be implemented and analyzed well.

The STEM approach also could build competencies such as curiosity, creativity, tolerance and ambiguity (Chang & Shih, 2019). This denotes that learning guides students in the process of growing creative thinking processes to solve various existing

problems. STEM can open opportunities for educators to introduce students to STEM concepts (Srikoom, Hanuscin & Faikhamta, 2017; Tippett & Milford, 2017; Kashdan et al., 2018; Margot & Kettler, 2019), techniques, and principles in a consolidated manner to develop products, processes, and systems used in learning.

The STEM approach to learning is able to give the impression of meaningful learning for students (Hobbs, Clark & Plant, 2018; Kurup, Powell & Brown, 2019). Systematic integration between science, technology, engineering, and mathematics can make students have better problem-solving skills and can increase students' knowledge in an integrated manner (Martín-Páez et al., 2019; Reynante., Selbach-Allen & Pimentel, 2020). The purpose of learning using the STEM approach is appropriate to be applied at the secondary school level where the subject in learning requires complex knowledge so that critical thinking skills will increase. However, from the data, it can be seen that STEM has not been able to increase numeracy abilities. Numeracy may require regular practice to improve, not only learning from a few meetings. This was confirmed by the students through interviews: "..except for numeracy, we need continuous practice because the problem is counting."

This study used a STEM approach for fluid materials. This will inspire other teachers to use STEM in other materials. From the results of this study, STEM is used to hone literacy and critical thinking skills (McClure et al., 2017; Sari, Selisne & Ramli, 2019; Shanta & Wells, 2020). Critical thinking has a significant role in making decisions and solving problems during the learning process and in everyday life. Critical thinking is needed to overcome the problems faced in life. With critical thinking, a person can regulate, adjust, change, or improve his thoughts so that he can act more appropriately (Caena & Redecker, 2019; Chien, Hwang & Jong, 2020). A critical thinker is a person who has skilled reasoning; a critical thinker uses his reasoning as an excuse. Critical thinking is thinking seriously, actively, and accurately in analyzing all information received with rational reasons.

Critical thinking is used in making informed judgments and explaining the reasons for solving problems (Brookfield, 2018). Critical thinking skills guide students' behavior and develop their beliefs. The results of the study on the madrasah students' abilities revealed a score of 76.55, indicating that it was categorized as good (see Table 2 and compare with the range score in Table 1). The results obtained are how students' abilities were in analyzing the questions provided. This third psychological aspect of

critical thinking is related to metacognition, which refers to one's knowledge, awareness, and control of one's thoughts. Although a person may have critical thinking skills and tend to use them (Wechsler et al., 2018; Royce, Hayes & Schwartzstein, 2019), that person will tend to use the skills appropriately if they do not know when to use them or if they lack knowledge of how to use them in certain situations.

Literacy and numeracy skills are often combined into one discussion. This is reasonable because, in general, when students have good literacy, it is proportional to numeracy abilities. In this study, the researchers tried to unravel literacy on their own. The findings exhibited that it was good, allowing students to read well about concepts and knowledge in science in learning. Literacy culture must be comprehensive at all levels of education. In a separate discussion, numeracy ability is someone in practical counting. Numerical ability is also the ability to use the interpretation of the results of the analysis to predict and make decisions. However, the results of this study indicate that in STEM-based learning, literacy skills were classified as good but not numeracy skills. Numeracy skills were only classified as neutral, namely 3.58 (see Table 3 and compare with the score range in Table 1)

At the end of this discussion, the researchers make the statement that STEM can foster critical thinking skills. Meanwhile, literacy skills are also categorized as good in line with critical thinking skills. However, students' numeracy skills tend not to improve; numeracy skills can be improved if students do numeracy exercises continuously. The numeracy skills produced by the STEM approach cannot be said to be optimal. This motivates the researchers to conduct further research to find the composition of STEM learning that can improve literacy and numeracy skills simultaneously.

D. Conclusion

The research findings revealed that critical thinking was in the good category (n=76.55), literacy was in the good category (n=3.58), and numeracy was in the neutral category (n=58.57). The STEM learning at Madrasah A went well and took place in a conducive manner. Meanwhile, the shortcoming of this research is that students' numeracy abilities have not been able to increase. This fact motivates researchers to conduct further research. However, the researchers found that students considered numeric skills not to be taught but were trained by students on a regular basis.

E. Acknowledgment

Thanks to all those who have helped in completing this research.

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