

Relationship between Scientific Literacy and Critical Thinking of Prospective Teachers

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ABSTRACT

The study aimed to analyze the relationship between scientific literacy and critical thinking in undergraduate primary school teacher education. The subjects in the study were 127 students majoring in the Faculty of Teacher Training and Education at a private university in Madiun, Indonesia. The type of research used is correlational research with the research instrument multiple-choice tests. Data analysis was performed using the Pearson correlation test using SPSS version 25, which had previously been tested for normality and homogeneity. The normality test results of critical thinking ability and scientific literacy data obtained sig. 0.406, the data has been normally distributed. Furthermore, the data tested for homogeneity and scientific data literacy sig. 0.679 and critical thinking data sig. 0.944, so that the data was declared homogeneous and continued with the Pearson correlation test, which obtained a sig. 0.44. The results showed a relationship between scientific literacy and the critical thinking of prospective teacher students. This result indicated that understanding science requires good thinking, especially critical thinking.

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1. INTRODUCTION

The challenges in the world of education are getting tougher; education must be able to form complete human resources and have the ability to solve problems in life. Human resources can be improved through the quality of learning that emphasizes the process. The learning process must provide direct experience in developing competencies in order to be able to understand and explore environmental conditions scientifically. The science learning process should assist students in achieving the goals, namely (1) Building meaningful knowledge and knowledge; (2) Providing freedom in developing thinking, creativity, and critical skills; (3) Applying the pre-existing knowledge to learn and solve problems, and make decisions. Lecturers are encouraged to produce active, interactive, and fun

learning methods so that the implementation of learning does not only emphasize the transfer of knowledge (Lowell&Moore, 2020). The same thing is also shown for designing education in the 21st century using innovative methods (Abadzi, 2016).

The science learning process still emphasizes providing materials or concepts without providing opportunities for students to develop their knowledge. The learning process based on explaining concepts only provides knowledge and benefits on a low scale (Arwita, Amin, Susilo, Zubaidah, 2016). Syarifah and Sumardi (2015) state that science learning is irrelevant in the view of students because the emphasis on understanding basic concepts and basic understanding of science is not related to matters related to the student environment and problems in everyday life. The observation results show that students are not accustomed to solving problems, which affects students' critical thinking skills are still low.

Based on a report from the United Nations Development Project (UNDP) in the Human Development Index (HDI), Indonesia has ranked 107 countries among various countries in the world (Human Development Report, 2020). This shows the low quality of science education in Indonesia. Science education in Indonesia emphasizes abstract conceptualization and does not develop active experimentation. The proportion of both should be balanced (Depdiknas, 2003). Student activity in class is less than optimal, resulting in 86.36% of students not experiencing increased critical thinking skills (Hariyadi, 2015). In line with this, Muhlisin (2016) stated that the critical thinking level of students in the introductory science concept course in the less critical category was 80.9%. Weisinger (2004) states that less than 1% of teachers in the United States train higher-order thinking skills in their students. This research shows that learning in Indonesia has not trained higher-order thinking skills (Listiani, 2018). However, many students still have low critical thinking skills in practice in the field (Din, 2020; Pieterse, Lawrence, & Friendrich-Nel, 2016).

Critical thinkers can give reasons for decisions that have been taken and are open to differences in the opinions of others and can listen to reasons for differences of opinion. Critical thinking is needed by someone to act or respond to events in an ordinary way but has the potential to be easily formed. Critical thinking skills are thinking processes that actively and skillfully conceptualize, apply, analyze, synthesize, and evaluate the information that has been collected. The ability to think critically is different from ordinary thinking. Critical thinking has the characteristics of being able to formulate, analyze, reflect, and evaluate from various perspectives. Therefore, critical thinking is often referred to as the most responsible think. The critical thinking process requires continuous observation and analysis of similarities and differences and causal relationships (Florea & Hurjui, 2015). Critical thinking is the ability to think systematically and reflect on reasoning. Critical thinking skills are needed to make the right decisions. Based on the description above, empowering critical thinking skills can equip students to analyze problems and make decisions to provide solutions to problems that exist in everyday life. Empowering critical thinking skills can equip students to improve scientific literacy skills.

Scientific literacy is critical for a person to adapt rapidly and increase competitiveness (Holbrook & Rannikmae, 2009; Foster & Shiel-Rolle, 2011; Laugksch, 2000; Salamon, 2007; Savedra & Opfer, 2012). Therefore, it is necessary to empower scientific literacy in elementary school students in learning, but there are still many research results that reveal that the scientific literacy ability of prospective teacher-students is still deficient (Akengin & Sirin, 2013; Rifqiyati, 2013; and Sulistiawati, 2015). Ristanto's study (2017) results through a science literacy ability test on students showed an average score of 40.63 for the context aspect, 38.07 for the content aspect, and 38.54 for the process aspect. These results show that students' scientific literacy scores are included in the low category of content, process, and context (Odja & Payu, 2014; Suciati, 2013). The ability of science and its application in learning can be influenced by teacher mastery in learning which is still low (Budiastra, 2011). Teachers have not linked learning materials with everyday life in the learning process (Ayas, 2001). This is because elementary school teachers and students do not yet have good scientific literacy, and the learning process is not optimal for improving scientific literacy skills (Cepni, 1997; Cepni & Bacan, 2012; Dahtiar, 2015; Sujana, 2014). Based on the description above, it can be concluded that scientific literacy is essential to be developed and taught

to prospective elementary school teaching students to manage activities that are oriented towards scientific literacy.

The development of scientific literacy in learning can be done by attracting students' involvement in learning activities and creating a conducive learning environment. Scientific literacy includes higher-order, social, and interdisciplinary thinking skills (Nbina and Obomanu, 2010). People who have scientific literacy can correctly use scientific concepts, principles, laws, and theories to interact with their environment and use scientific processes to solve problems, make decisions, and then understand the actual state of nature (Laugksch, 2000). Students can learn based on the experiences they have experienced in everyday life, which are integrated with the knowledge gained from scientific literacy. So that students can think critically in solving problems in everyday life.

The results of previous research conducted by Rahayuni (2016) found a link between critical thinking skills and scientific literacy using two different treatments. The same thing was found in the research results by Pamungkas et al., that the achievement of students' scientific literacy is influenced by critical thinking skills and metacognition (Pamungkas et al., 2018). In contrast to the two studies above, this study only focuses on two abilities that are seen to be tested for their relationship and influence on prospective elementary school teacher students.

2. METHODS

Research Design

This research is quantitative research with the type of correlational method. According to Creswell (2014), quantitative correlational research uses statistical methods that measure the influence of two or more variables. This study wants to test scientific literacy and critical thinking in prospective elementary school teacher students.

Participants

The students involved in the research are students in the fifth semester of the 2020/2021 academic year of the elementary teacher education study program at PGRI Madiun University, with a total of 187. The research sample was obtained using the proportionate stratified random sampling technique and calculated by the Solvin formula (Darmawan, 2014).

$$n = \frac{N}{1 + N(e)^2}$$

Description:

n = sample size

N = population size

e = allowance for inaccuracy due to tolerable sampling error (1%, 5%, 10%)

*in this calculation the researcher uses 5%

The calculation results have obtained a sample of 127 students divided into 4 classes. The samples came from classes A, B, D, and E, which were then given treatment in the form of test questions. The questions used are descriptive questions to measure critical thinking and multiple-choice questions to measure scientific literacy. The number of questions used is 6 essays and 17 multiple choices.

Data Collection and Analysis

Data collection was obtained from the results of critical thinking and scientific literacy tests. The researcher continued to collect data by giving questions that had been tested on 5th-semester students of classes A, B, D, and E. The results of student work were then corrected and analyzed by doing a correlation test. Furthermore, the data in this study were processed using the SPSS version 25 application. In the first stage, the researchers conducted descriptive data analysis. The second stage

carried out the classical assumption test (precondition test). The student's critical thinking and scientific literacy scores have been standard and homogeneous based on the test results. Then parametric testing can be carried out using the correlation test. In the third stage, the researcher tested the hypothesis. Data analysis was performed using the Pearson correlation test using SPSS version 23.

Instrument

The instrument used in the research was a test of critical thinking with essay and multiple-choice questions to assess scientific literacy. Indicators of critical thinking skills and scientific literacy in full can be seen in Table 1 and Table 2 as follows:

Table 1. Critical Thinking Ability Indicator

No	Aspect	Indicator
1	Interpretation	Understand and express the meaning of various experiences, situations, etc Recognizing expected and actual inferential relationships
2	Analysis	Recognizing and obtaining the elements needed to draw reasonable
3	Conclusion	conclusions
4	Evaluation	Assess the credibility of statements or other representations
5	Explanation	Presenting considerations in the form of solid opinions
6	Self-regulation	Monitoring his knowledge

(Source: Facione, 2011)

Table 2. Scientific Literacy Indicator

No	Aspect	Indicator
1	Role of science Scientific	1) Identify questions that can be answered through scientific investigation 2) Understand the nature of the scientific activity 3) Understand the concept of science
2	Thinking and doing	1) Explaining natural phenomena 2) Recognize patterns 3) Identify research variables 4) Asking critical questions about research design 5) Giving/evaluating conclusions based on evidence
3	Science and society	1) Apply scientific decisions in daily life 2) Understand the role of science in making decisions 3) Develop questions to assess the validity of scientific reports 4) Asking the source of scientific reports 5) Identify scientific issues that underlie policy decisions
4	Mathematics in science	1) Using math in science 2) Understand the application of mathematics in science
5	Science motivation and beliefs	1) Source and certainty of scientific knowledge

(Source: Forest et al., 2014)

Procedure

The research was conducted for one semester or 16 meetings. The researchers gave a lesson to the students in 14 meetings, and two meetings were for exams. The stages in the research began with compiling research instruments, which consisted of test questions on critical thinking skills and scientific literacy of prospective teacher students. The instruments that have been compiled were tested for readability by experts. The readability test asks the expert to examine the suitability between the indicators and the questions. The test results show that several questions can be used 1, for example, in

explaining natural phenomena and identifying scientific issues that underlie policy decisions. Then the researchers made revisions based on the suggestions and input given; 20 multiple-choice questions were selected, and only 17 questions were used in data collection. The data was taken after being given treatment in the form of learning.

3. FINDINGS AND DISCUSSION

The description of scientific literacy and critical thinking data from this research can be described in Tables 1 and 2 below:

Table 1. Scientific Literacy Test Results

Statistical Result	Class			
	A	B	D	E
60,0 – 64,9	2	0	2	2
65,0 – 69,9	5	4	4	2
70,0 – 74,9	5	5	5	3
75,0 – 79,9	12	9	7	8
80,0 – 84,9	8	12	14	10
85,0 – 89,9	0	2	0	4
90,0 – 94,9	0	0	0	3
N Valid	32	32	32	31
Missing	0	0	0	0
Mean	74,062	76,906	72,078	78,047
Median	70,0	78,75	71,25	77,5
Std. Deviation	7,2052	5,497	6,999	7,4794
Variance	51,915	30,217	48,986	55,941
Minimum	60,0	67,5	62,5	60,0
Maximum	82,5	87,5	82,5	90,0

Based on the table above, the study results show that the scientific literacy value of class A has an average (mean) of 74,062, with the lowest value of 60.0 and the highest of 82.5. Class B has an average (mean) of 78,906, with the lowest score of 67.5 and the highest of 87.5. Class D has an average value (mean) of 78.047, with the lowest score of 62.5 and the highest being 82.5. Meanwhile, for class E, the average (mean) is 78.047, with the lowest score of 60.0 and the highest of 90,0.

Table 2. Critical Thinking Test Result

Statistical Result	Class			
	A	B	D	E
60,0 – 64,9	0	2	1	0
65,0 – 69,9	3	4	4	2
70,0 – 74,9	8	5	5	3
75,0 – 79,9	9	7	8	7
80,0 – 84,9	7	9	12	8
85,0 – 89,9	4	3	2	9
90,0 – 94,9	1	2	0	2
N Valid	32	32	32	31
Missing	0	0	0	0
Mean	79,293	74,409	78,218	79,077
Median	78,0	76,75	76,25	78,5
Std. Deviation	7,2052	5,497	6,999	7,4794
Variance	16,691	12,381	14,594	23,215
Minimum	66,0	62,5	64,5	68,0

Statistical Result	Class			
	A	B	D	E
Maximum	92,5	97,5	87,5	93,0

Table 2. shows that the critical thinking value of class A has an average (mean) of 79,293, with the lowest value of 66.0 and the highest of 92.5. Class B has an average (mean) of 74,409, with the lowest score of 62.5 and the highest of 97.5. Class D has an average value (mean) of 78.218, with the lowest score of 64.5 and the highest being 87,5. Meanwhile, for class E, the average (mean) is 79.077, with the lowest score of 68.0 and the highest of 93,0.

The results of the research on critical thinking skills, scientific literacy, and the relationship between critical thinking skills and scientific literacy can be described as follows:

1. The Result of Scientific Literacy of Prospective Teacher Students

The data on the average value of Science Literacy can be shown in Table 3 as follows:

Table 3. Average Value of Scientific Literacy

Variable	Aspect					Average
	1	2	3	4	5	
Scientific Literacy	0,51	0,67	0,75	0,74	0,85	0,71

Based on Table 3, the average value of scientific literacy for prospective teacher-students is 0.71 from a maximum value of 1. This shows that the percentage of scientific literacy scores is 70.53%. The complete data for each aspect of scientific literacy can be seen in Figure 1 as follows:

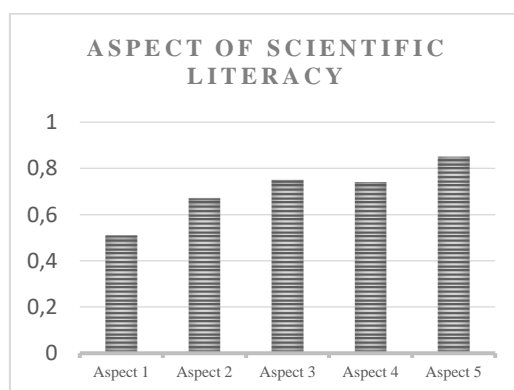


Figure 1. An aspect of Scientific Literacy

Figure 1 shows the average score of each aspect of science literacy for prospective teacher students. The lowest score is indicated by aspect 1, namely the role of science. The highest score is in aspect 5, namely motivation and belief in science. This score has the highest value because students already have confidence in science.

2. The Result of Critical Thinking Ability of Prospective Teacher Students

The data on the average value of Critical Thinking Ability can be shown in Table 4 as follows:

Table 4. Average Score of Critical Thinking Ability

Variable	Aspect						Average
	1	2	3	4	5	6	
Critical Thingking Skills	7,77	7,17	7,71	7,36	7,47	6,29	7,30

Based on Table 4, the average value of students' critical thinking skills is 7.30, with a maximum value of 10. This shows that the percentage of students' critical thinking skills for teacher candidates is 72.97%. Data for each aspect of critical thinking skills in full can be seen in Figure 1 as follows:

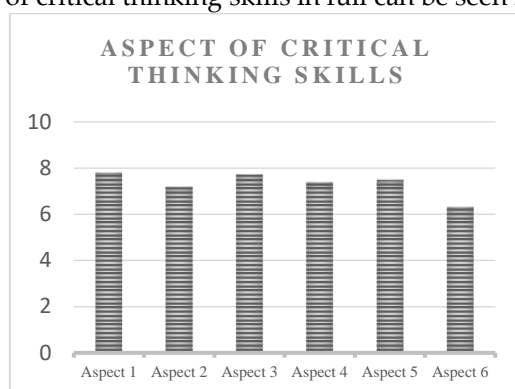


Figure 2. The Aspect of Critical Thinking Skills

Figure 2 shows the average score of each student teacher's critical thinking ability aspect. The lowest score is indicated by aspect 6, which is self-regulation. The highest score is in aspect 1, namely interpretation. This score has the highest value because students have been able to understand and express the meaning of the significance of various experiences or situations they have experienced.

3. What is the Relationship between Critical Thinking Ability and Scientific Literacy of Prospective Teacher Students

The data on the value of critical thinking skills and scientific literacy were then tested for normality and homogeneity. The test results can be seen in Table 4 as follows:

Table 4. Normality and Homogeneity Test Results of Critical Thinking Ability and Scientific Literacy

Type of Test	Data	Conclusion Test	Results
Normality	Critical Thinking Skills & Scientific Literacy	.406	Test results > 0.05, so the data is declared normally distributed
	Critical Thinking Skills	.944	Test results > 0.05, so critical thinking ability data can be declared homogeneous
Homogeneity	Scientific Literacy	.679	Test results > 0.05, so critical thinking ability data can be declared homogeneous

The data was then tested for correlation to determine the relationship between critical thinking skills and scientific literacy. The data from the correlation test results are shown in Table 5 as follows:

Table 5. Result

Type of Test	Hasil	Kesimpulan
Correlation	.044	Test results < 0.05, so that it can be stated that there is a relationship between critical thinking skills and student scientific literacy

The results of the hypothesis test show there is a relationship between scientific literacy and critical thinking. This can be seen in Table 5 results. This study found that the students' ability to give meaning, interpret, translate, and express concepts were influenced by scientific literacy variables and variables critical thinking. Scientific literacy emphasizes the importance of thinking (Suwono et al.,

2015) and involves the mastery of thinking by recognizing and addressing several issues growing in society. Scientific literacy can develop in line with the development of reasoning skills and academic thinking in social life. The results of this study mean that someone who has high scientific literacy skills and high critical thinking.

Gueldenzoph & Mark (2008) stated that an active learning environment involving students investigating information and applying knowledge would promote students' critical thinking skills. Jacobsen et al. (2009) stated that critical thinking could be pursued by building a classroom climate that genuinely values thinking and analysis. Sadia (2008) suggests that critical thinking cannot be taught through the lecture method because critical thinking is an active process learned through the actualization of appearance (performance). Critical thinking can be taught through laboratory activities, inquiry, term papers, group discussions, homework which provides various opportunities to stimulate critical thinking skills, and exams designed to build critical thinking skills. High-level questions can encourage deeper critical thinking.

Thinking processes and abilities include defining and analyzing problems, formulating principles, observing, clarifying, and communicating (Swarabama, 2013). Critical thinking skills are mental processes for analyzing arguments and questions and processing information (Suryobroto, 2010; Geng, 2014). Critical thinking skills are used to analyze problems critically to improve the quality of thinking and skill in making decisions by using their thinking in a structured and reasonable way to evaluate their own beliefs and opinions (Ennis, 2011; Facione, 2013; Greinstein, 2012; Johnson, 2011; Paul&Elder, 2008).

Ranikmae (2009) suggests that good learning outcomes are obtained from meaningful learning. The direct involvement of students in learning shows that learning does not only consider the knowledge of concepts and theories obtained but must be based on considerations that lead to an investigation process so that students can better understand science; they can solve science problems, both orally and in writing. This is in line with the opinion of Toharudin (2014) that every individual must have the ability to understand science, communicate science both orally and in writing, and apply the acquired scientific knowledge to be able to solve problems so that they have a high attitude and sensitivity towards themselves and the environment. In making various decisions based on scientific considerations, to improve students' scientific literacy skills.

The role of scientific literacy in learning is to develop a positive attitude towards science. Scientific literacy in learning provides a new perspective for students to understand more about science. Learning emphasizes achieving an integrated understanding (Krajcik et al., 1999). Students gain knowledge to relate the material learned in class to the context of their lives. Students can also link science and technology to learning at school is practical and valuable in life. One of the dimensions of studying science is that science learning is intended to obtain a relationship between science and technology and society (Chiapetta & Koballa, 2010).

4. CONCLUSION

The results of the hypothesis test show there is a relationship between scientific literacy and critical thinking. This indicates that understanding science thoroughly requires good thinking skills. Understanding the various meanings and events experienced and having faith in science are reasonable provisions for optimizing these two abilities.

The drawback of this study was that the sample was limited to classes A, B, D, and E only. The shortcomings in this study will be used as reflective material for the author to conduct similar research using different treatments and to conduct further research using a larger sample. The research effectively provided learning treatments that could trigger students' critical thinking skills and scientific literacy.

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