JPPIPA 9(9) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Examining the Correlation between Critical Thinking and Problem-Solving Skills of Junior High School Students Against Climate Change

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Received: June 24, 2023
Revised: September 6, 2023
Accepted: September 25, 2023
Published: September 30, 2023

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DOI: 10.29303/jppipa.v9i9.4438

Abstract: This research examined the association between critical thinking and problem-solving skills among junior high school students, specifically focusing on Climate Change. The participants in this study included 272 students from XYZ Junior High School Rangkasbitung, comprising grades 8 and 9, during the even semester of the 2022/2023 academic year. A previously validated multiple-choice instrument with four answer choices assessed their abilities. The collected data were analyzed using SPSS 23 to determine the correlation and Winstep 5.4.1 for categorizing students' abilities. The findings revealed that the students obtained an average score of 42.82 for critical thinking and 43.53 for problem-solving skills. The correlation coefficient was calculated to be 0.74, indicating a strong and positive relationship between critical thinking and problem-solving skills. It was observed that an increase in the critical thinking score accompanied an increase in the problem-solving score. Additionally, the determination value of 0.546 indicated that critical thinking skills could explain 54.6% of the variance in problem-solving skills, while other factors influenced the remaining 45.4%.

Keywords: Climate change; Correlation; Critical thinking; Problem solving; Relationship

Introduction

The Assessment and Teaching of 21st Century Skills (ATC21S) research project classifies four skill groups crucial to master in the modern era. According to Binkley et al. (2012), one of those groups is ways of thinking: creativity and innovation; critical thinking, problem-solving, and decision-making; learning to learn and metacognition (Van Laar et al., 2020). Thinking skills play a crucial role in effectively navigating life's challenges. These skills encompass critical thinking, creative thinking, and problem-solving abilities (Kalelioğlu et al., 2013). Thinking critically is essential for individuals to address the diverse problems encountered in their social and personal lives. Multiple definitions of critical thinking exist, with Facione (2020) asserting that it involves self-regulated decision-making processes encompassing interpretation, analysis, evaluation, and inference. Furthermore, critical thinking involves utilizing evidence, concepts, methodologies, criteria, and contextual factors to inform decision-making.

Critical thinking holds inherent value in scientific practice and significant potential in science education. Its importance and role in science education, as well as in education in general, are indisputable. From the 1980s to now, critical thinking has increasingly found its place in curricula through various approaches (Santos, 2017). Critical thinking manifests within processes tied to scientific methods and research, such as observation and exploration (Demir, 2015), and contributes to constructing reliable knowledge (Osborne, 2014). Demir (2015) emphasized the significance of developing critical and reflective thinking skills to enable individuals to view, think about, research, question, and scientifically address events. To think critically, individuals must possess domain-specific knowledge to form

How to Cite:
Perdani, A.S., Hernani, H., & Ramalis, T.R. (2023). Examining the Correlation between Critical Thinking and Problem-Solving Skills of Junior High School Students Against Climate Change. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 6904–6910. https://doi.org/10.29303/jppipa.v9i9.4438

independent, well-founded perspectives or opinions (van de Oudeweetering et al., 2018).

Critical thinking is a cognitive process that allows us to perceive the world using our existing knowledge. Problem-solving, another equally important concept, plays a crucial role. Individuals encounter challenges throughout their lives, and to overcome them; they need to organize their background knowledge and engage in mental processes (Kirmizi et al., 2015). The ability to solve problems is essential for students to thrive in the global landscape of the 21st century (Dewi et al., 2017). Assessing student's problem-solving skills becomes necessary to gauge the effectiveness of innovative learning methods. By measuring student's problem-solving abilities, we can evaluate their preparedness to tackle the challenges of the modern era.

Problem-solving is a fundamental aspect of the cognitive process. Problem-solving is a higher-level cognitive process that demands more regulation and control than routine or basic skills (Jayadiningrat et al., 2018). Problem-solving involves organizing concepts and skills into novel patterns to achieve the objective of a problem that cannot be easily solved using established procedures (Annizar et al., 2020). Whether a question is considered a problem depends on the cognitive abilities of the individual attempting to solve it. What may not be a problem for one person can pose a challenge for another. For instance, a linear system question with two variables is no longer a problem for middle school students as it becomes a routine task. Still, the same question can present a challenge for elementary students. Hence, problem-solving necessitates profound thinking and the integration of previously acquired knowledge. It entails establishing connections between current problems faced by students and problems encountered in the past. In addition to solving problems, it involves selecting an approach method, recognizing when to step back and reconsider an unproductive method, and engaging in introspection and reflection upon the obtained solution (Annizar et al., 2020).

Problem-solving involves utilizing mental and physical capabilities to address challenging situations. Science education should prioritize a deep understanding of concepts, enabling students to develop skills in critical thinking and a logical approach to problem-solving (Hiremath, 2015). Problem-solving entails a purposeful sequence of cognitive operations wherein the solver devices and implements plans within specific constraints to move from the current state towards the desired goal state (Kim et al., 2014). The ability to solve problems involves identifying a problem and taking appropriate steps to resolve it. Acquiring problem-solving skills entails obtaining knowledge that leads to potential solutions and integrating and applying that knowledge effectively to find a resolution (Kim & Choi, 2014).

Problem-solving skills are essential when facing complex and uncertain situations that lack prior examples or precedents (Keane et al., 2016). The concept of problem-solving encompasses the knowledge and abilities needed to navigate and address complex, nonroutine situations effectively (Funke et al., 2018). While domain-specific knowledge is significant, problem-solving goes beyond relying solely on prior knowledge. It also involves the ability of an individual to recognize necessary actions, potential gaps, and the steps required to acquire essential information (Rausch et al., 2016).

Developing critical thinking and problem-solving skills is essential when learning about the environment, as student's knowledge mastery does not solely influence environmental attitudes. As members of the academic community, students are expected to actively preserve and protect the environment while also addressing environmental issues, fostering a positive environmental attitude within themselves (Fua et al., 2018). However, in reality, many students lack awareness of their campus environment. Insufficient environmental knowledge can hinder student's critical thinking abilities and awareness of environmental matters (Ahmadi et al., 2018). Climate change is one of the environmental topics covered in the curriculum for junior high school students. This subject involves studying concepts such as the definition of global warming and climate change, the greenhouse effect, greenhouse gases, and strategies to mitigate global warming.

Critical thinking and problem-solving skills are not innate but can be developed through learning and assessments. Educators are crucial mediators and facilitators in designing and implementing methods, models, or strategies that train and enhance student's critical thinking and problem-solving skills. Education aims to teach students to think critically (Kalelioğlu et al., 2013). Educators can effectively train student's critical thinking and problem-solving abilities by creating a learning environment that fosters independent knowledge-building. The research conducted by Irfaner (Alcantara & Bacsa, 2017) emphasizes that the absence of critical thinking skills in the classroom significantly hampers student's chances of success.

In the 2013 curriculum, science learning emphasizes developing critical thinking skills and problem-solving to enhance student's knowledge and understanding. Students are expected to achieve the competency standards set in the curriculum through activities that involve explaining, analyzing, applying, presenting, and communicating (Kemdikbud, 2018).

This highlights the importance of aligning the process and assessment of science learning towards cultivating student's critical thinking and problem-solving abilities.

Assessing the competence of critical thinking skills and problem-solving as achievement targets in science learning should occur during and after the learning process. Therefore, it is necessary to employ assessment instruments that yield accurate and precise data/information regarding the quality and progress of student's critical thinking skills and problem-solving abilities. This research aims to analyze and determine the correlation between student's critical thinking and problem-solving skills. This analysis will provide valuable input for teachers to design appropriate learning activities and enhance student's critical thinking abilities.

Method

In this study, the researchers employed the correlational research method to examine the critical thinking and problem-solving skills levels among public junior high school students and determine the correlation between these skills. The sampling method used was convenience sampling, a nonprobability sampling technique. The participants included 272 students from XYZ public junior high school in Rangkasbitung. The data collection took place in the 2023 semester, and the students were given 60 minutes to complete the test. The number of participants has met the minimum number in correlational studies. Fraenkel et al. (2023) stated that a sample of at least 50 is deemed necessary to establish the existence of a relationship.

To assess the student's critical thinking and problem-solving skills about the climate change concept, an instrument called the Critical Thinking and Problem-Solving (CT-PS) assessment tool was utilized. The instrument consisted of 42 items, with 24 items focusing on critical thinking (CT) and 18 items addressing problem-solving (PS). The CT indicators were adopted from Facione (2020), while the PS IDEAL model steps were adopted from Bransford and Stein (Annizar et al., 2020)), and the indicators were adopted from Annizar et al. (2020). The instrument used a multiple-choice format, with four answer choices provided for each item. Student responses were scored as dichotomous data, with "0" indicating incorrect answers and "1" denoting correct answers. Table 1 presents the design of the critical-thinking and problem-solving instrument test (CT-PSt).

Table 1 Design of 42 Ttems CT-PSt

Skills	Aspect	Indicators
Critical Thinking	Interpretation	clarify meanings
		categorize
	Analysis	examine ideas
		identify reasons and claims
	Inference	conjecture alternatives
		draw logically valid or justified conclusions
	Evaluation	assess credibility of claims
		assessing quality of arguments made using deductive or inductive reasoning
	Explanation	justify procedure
		state results
	Self-regulation	self-monitor
		self-correct
Problem-Solving	Identifying the problem	describing the question given using their language
		understanding every word in the question given
	Defining and representing the problem	mentioning information that is known in the question completely
		using picture, table, symbol or other form of representation
	Exploring possible strategies	preparing several problem-solving strategies
		choosing a strategy from several alternatives
	Acting on the strategies	implementing the chosen strategy correctly
	Looking back and evaluating	correcting calculations
		correcting concepts

The Rasch Model with Winstep 5.4.1 software analyzed mean, standard deviation, Cronbach Alpha, item measure, and person measure data. SPSS 23 (Statistical Package for Social Sciences) statistical software was used to analyze the data obtained in the research. Pearson correlation coefficients and determination values were analyzed to determine the relationship between critical thinking and problem-solving skills.

Result and Discussion

Students Ability

Students' abilities were analysed using the Rasch model with the Winstep 5.4.1 tool. According to Rasch (1960)(cited in Bond & Fox, 2015), higher-ability individuals are more likely to answer questions correctly. Similarly, items with higher difficulty levels are less likely to be completed than other items. The Rasch model produces a logit scale, representing equal intervals and linear relationships derived from odds ratios rather than raw score data. This allows for a more precise estimation of a person's ability or the difficulty level of questions, enabling meaningful comparisons as they share the same unit (logit). In the Rasch model, item analysis is conducted individually for each item. Furthermore, the Rasch model simultaneously evaluates respondents, examining consistent response patterns, such as agreement (in attitude assessments) or random responses.

This study used the CT-PSt instrument, consisting of 42 items that test critical thinking and problem-solving skills. The reliability of the student's test responses was assessed using Cronbach's Alpha (KR-20), a measure of internal consistency (Sekaran, 2019). The value of Cronbach's Alpha, which indicates the consistency between the items and the individuals, was found to be 0.86, placing it in the excellent range (Sumintono et al., 2015). The item reliability of the CT-PSt was highly reliable, with a value of 0.95. This index assesses the consistency of an item's measurement within a set of items and the measured variable when administered to a different group of individuals with similar abilities (Bond et al., 2015).

The person reliability index measures the consistency of person assignments that would be expected if a different set of suitable questions were given to the same group of individuals, testing the same construct (Bond et al., 2015). For the CT-PSt, the person reliability was 0.85, indicating good reliability (Sumintono et al., 2015). A person separation index indicates the spread or differentiation of individuals based on the measured variable (Bond et al., 2015). The value of the person separation index for the CT-PSt was more significant than one, precisely 2.34, indicating enough samples to distinguish between different levels of human abilities (Gracia, 2005).

A more exact formula, H = [(4 x separation + 1)/ 3], is used to calculate the separation value (Sumintono et al., 2015). Therefore, the value for separation for the person is 2.3. The study participant's abilities were divided into high, moderate, and low. The mean and SD of all LVP values were used to group the student's abilities. Of the 272 students, it was found that 11% of students had high abilities, 32% had moderate abilities, and 57% had low abilities. Based on these data, half of the students have low abilities. In addition, based on evidence by a person logit mean of -0.31 logit, all respondents in the study were found to have the below-average ability (below the item mean) in the CT-PSt. CT and PS data processing were then carried out separately so that CT's mean person measure was -0.33 and PS's mean person measure was -0.31. The two logit values of the mean person measure are lower than the mean item measure (0.00), indicating that the student's ability is lower than the item's difficulty level. It can be said that student's critical thinking skills and problem-solving are weak.

Table 2. Descriptive Statistics on Students' CT-PS with Rasch Model

Skills	Mean	Mean Item Measure	Mean Person Measure
CT-PS	-	0.00	-0.31
CT	42.82	0.00	-0.33
PS	43.53	0.00	-0.31

The collected data is then evaluated that measure CT skills. The results of the measure, which yielded the students' average CT scores, are shown in Table 2. The average student score for CT is 42.82. This means scores are still relatively small. There are several potential reasons why students' CT skills scored poorly, including their conceptual understanding. To be able to think critically, students must have a fundamental skill called idea mastery. The low degree of students' CT abilities is also a result of their limited exposure to its growth during learning. It is impossible to develop CT without practice naturally. However, CT needs to be stimulated to be developed and improved. CT skills should ideally be taught to junior high school students as part of the educational process. The teacher should be able to provide educational materials that promote students' CT abilities.

The computation results in Table 2 also show the average score for PS ability. The average score for students' abilities to solve problems is 43.53. This mean score is still relatively small. The student's exposure to problems is likely why their PS skills scored poorly. Due to insufficient exposure to problems during learning, children did not develop the necessary PS skills.

CT and PS Correlation

Analysis of normality and homogeneity of data regression was carried out before carrying out the Pearson correlation test using SPSS 23. Based on the Kolmogorov-Smirnov normality test results with unstandardized residual data with a Sig. (2-tailed) is 0.200. Sig. (2-tailed) mean that the value is significant at a significance level of 1% or 0.01. This value is more significant than 0.05, meaning 272 students' CT and PS data are typically distributed. In addition, the Levene homogeneity test was also carried out so that a Sig value of 0.138 was obtained which was greater than 0.05. This value means the 272 students' CT and PS data are homogeneous.

Table 3. Correlations of CT and PS Skills

Aspect	CT	PS
Pearson correlation	1	0.740*
Sig. (2-tailed)		0.000
N	272	272
Pearson correlation	0.740*	1
Sig. (2-tailed)	0.000	
N	272	272

*Correlation is significant at the 0.01 level (2-tailed)

The relationship between CT and PS abilities was also examined using the Pearson correlation method with r xy at = 0.01. From the output Table 3, a coefficient of 0.740 is obtained, which means the strength of the relationship or correlation between CT and PS is strong. An asterisk (*) indicates that the correlation is significant at a significance level of 1% or 0.01. In addition, the correlation coefficient number is positive (0.740), which means that the relationship between CT and PS is unidirectional. Thus, it can be interpreted that an increase will follow an increase in the CT score in the PS score. To see whether the relationship that occurs is significant or not is based on the significance value or Sig. (2-tailed) of 0.000, which is smaller than 0.05. It means a significant relationship exists between CT and PS. Therefore, it can be concluded that at a significance level of 1%, there is a positive and robust relationship, namely 0.740, between critical thinking scores and problem-solving scores.

Table 4. Aspects Correlations of CT and PS

Aspect	PS1-Identifying the problem	PS2-Defining and representing the problem	PS3-Exploring possible strategies	PS4-Acting on the strategies	PS5-Looking back and evaluating
CT1-Interpretations	**0.368	**0.284	**0.335	**0.397	**0.312
CT2-Analysis	**0.407	**0.246	**0.375	**0.327	**0.263
CT3-Inference	**0.401	**0.305	**0.305	**0.320	**0.369
CT4-Evaluations	**0.351	**0.347	**0.354	**0.392	**0.346
CT5-Explanation	**0.291	**0.363	**0.322	**0.305	**0.346
CT6-Self regulation	**0.387	**0.307	**0.419	**0.310	**0.267

**Correlation is significant at the 0.01 level (2-tailed)

Correlation analysis of each CT-PS aspect was also performed. Based on correlation data processing also obtained Sig. 2-tailed 0.000 for each correlation data between aspects of CT and PS. The Sig 2-tailed value is less than 0.05, indicating a correlation or relationship between CT and PS. In addition, based on the results of processing correlation data in Table 4, it is known that each aspect of critical thinking skills and problem-solving has a higher r count than the r table (r table 1% for N 272 = 0.1554). This value means a positive correlation exists between each aspect of CT and PS. It can be interpreted that an increase will follow an increase in the CT score in the PS score.

Table 5. R Square Value

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.740	0.548	0.546	12.80741

The correlational result is shown in Table 5 after correlational statistic calculation using Pearson correlation with r_{xy} on = 0.01 between CT-PS skills. The correlation between students' CT-PS skills on the climate change topic is seen in Table 6 (r = 0.74). This outcome shows that students' CT is growing concurrently with their problem-solving skills. The capacity for problem-solving grows along with the ability for CT. Conversely, as one's capacity for CT declines, so does one's capacity for problem-solving. According to the determination value in Table 8 (R2 = 0.546) included in the category of strong fit (Cohen et al., 2018). The R square value means 54.6% of PS skills can be described by CT skills, and other variables influence 45.4%. The results show a strong relationship between CT and PS abilities.

The results of this study are in line with previous studies which also managed to find a positive correlation between CT and PS (Kim et al., 2014; Kirmizi et al., 2015; Lismayani et al., 2017; Susanti et al., 2019). CT makes students actively search for solutions to problems during problem-solving, making it a crucial component of problem-solving comprehension. Critical thinking plays a role in decision-making and problem-solving by evaluating and accepting opinions (Yoon, cited in Jeong, 2015). In the process of learning science, the capacity for CT-PS skills must be developed and can be learned. The optimum way to teach science is to emphasize both competencies. In addition to being given the material, students also build their knowledge.

Conclusion

Based on mean person measure, all respondents in the study were found to have below-average ability (below the item mean) in the CT-PSt, indicating that the student's ability is lower than the item's difficulty level. It can be said that student's critical thinking skills and problem-solving are weak. The relationship or correlation between CT-PS is solid and positive, which means that the relationship between CT-PS is unidirectional. Thus, it can be interpreted that an increase will follow an increase in the problem-solving score's CT score. 54.6% of PS skills can be described by CT skills, and other variables influence 45.4%. In the process of learning science, the capacity for CT-PS skills must be developed and can be learned. The optimum way to teach science is to emphasize both competencies. In addition to being given the material, students also build their knowledge.

Acknowledgments
This research is supported and funded by Indonesia Education Fund (BPI). Therefore, we would like to thank LPDP, Puslapdik, and the Ministry of Education and Culture for providing the funds so that this research can be carried out until the research journal is published. We also thank all parties who have helped to complete this research correctly.

Author Contributions
In this study, the authors are split into advisors and executor.

Funding
There was no external funding for this study.

Conflicts of Interest
The author declares no conflict of interest in this research.

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