RESEARCH ARTICLE

The complexity science problem-based learning: Correlation of science literacy and concept mastery to problem-solving skills

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Abstract: Science and technology are rapidly developing in the 21st century which requires educators to facilitate real-life problem-based learning activities and the application of science that can stimulate problem-solving skills with science considerations. This research aims to determine the correlation of science literacy and concept understanding with students' problem solving skills and variables that are more influential in improving problem solving skills. The research sample consisted of 34 students of eleventh class of State Senior High School (SSHS) 6 of Malang who took Biology as an elective subjects. The variables measured in this study, namely predictor variables (science literacy and concept understanding), and criterion variables (problem solving skills). The data of the three variables were obtained from an essay test at the end of the lesson and then analyzed using multiple linear regression test. The results showed that the predictor variables (science literacy and concept mastery) gave a relative contribution to problem solving skills with a percentage of 72.1% and 27.9%, respectively. Science literacy variable is more influential on improving problem solving skills than concept mastery. The results of this study indicate a positive correlation between science literacy and concept understanding with problem solving skills.

Keywords: concept mastery; CS-PBL; problem solving skills; science literacy

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Introduction

Every individual complex problems in the current era of globalization and technological advancement. Complex problems occur because there are various components and aspects of interaction with the environment that must be considered for problem solving (Tomé & Açıkalın, 2019). Problem solving skills are fundamental skills related to higher-order thinking that need to be possessed by every individual to overcome problems (Graesser et al., 2019; Laar et al., 2018). Individuals apply what they know to understand problems and create workable solutions (Kozikoğlu, 2019). Students who understand science can overcome various complex problems in the 21st century (Sari et al., 2024).

Science literacy is the ability to recognize, explain, apply science and make decisions related to scientific knowledge in various complex life conditions (OECD, 2022). Science literacy involves asking questions about life and seeking answers based on scientific considerations (Mahanal et al., 2020). Science literacy is very important to be empowered to prepare students to develop in accordance with changes in social life (Zubaidah, 2019). Science literacy can increase a high level of concern for the environment (Rohmaya, 2022). Science literacy facilitates students ability to actively build and construct knowledge and then understand and apply it to solve problems (Az-Zahra et al., 2021). Science literacy is closely related to mastery of science concepts including a deep understanding of the theories, principles, and facts of science underlying natural phenomena (Ogunkola, 2013).

Concept mastery is related to the cognitive process of each individual. Concept mastery is the ability to understand, understand, and apply knowledge about certain concepts in various situations to solve

problems or explain phenomena (Amanda et al., 2021). The levels of cognitive processes according to the revised version of Bloom's taxonomy in Krathwohl (2002) are remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). The cognitive dimensions of analyzing, evaluating, and synthesizing encourage students to master complex concepts (Gultepe, 2016). A deep understanding of science concepts is key to developing good science literacy (Vieira & Tenreiro-vieira, 2016). On the other hand, problem-solving skills are one of the important skills to master in science education, as it involves applying science to identify problems, analyze information, generate solutions, and evaluate the results (Care et al., 2016).

Problem solving skills are skills to identify, analyze, solve problems effectively and efficiently (Glazewski & Ertmer, 2020; Pólya, 2004). Problem solving skills are very important to master because they help students to apply the knowledge they have gained to real and complex situations, and can improve understanding of science concepts by getting used to thinking systematically (Fischer et al., 2012). Concept mastery is very useful in the process of finding the right solution to problem solving with various scientific considerations (Jena & Panda, 2017). The results of research by Amanda et al. (2021) also stated that there is a significant relationship between concept mastery and problem solving. Problem solving skills can help students overcome everyday problems (Yuliana et al., 2020). Complex problem solving requires higher-order thinking skills that involve thinking abilities that involve analysis, problem evaluation, and application of various knowledge and skills as the basis of problem solving (Almulla, 2023; Peter, 2012). The development of science literacy and concept mastery is necessary because it can make students not only memorize content but can be more complex in problem solving (Mubarokah et al., 2021; Sari et al., 2024). Science literacy, concept mastery, and problem solving skills of students can be empowered by applying contextual problem-based learning models and learning that trains systematic thinking to find solutions to problems (Vieira & Tenreiro-vieira, 2016). One of the solutions is to apply the Complexity Science-Problem Based Learning (CS-PBL) model in learning.

CS-PBL learning model is multidiscipline in the foundation and facilitates students to train themselves to solve problems relevant to their lives (Amanda et al., 2022). CS-PBL applies the complexity science approach and the principles of Problem-Based Learning (PBL). Complexity Science (CS) is an approach to train students in how to think in problem solving to produce rational solutions (Aldrich, 2008; Fogelberg & Frauwirth, 2010). PBL is a student-centered learning model based on real-world problems to help students develop problem-solving skills and understand essential concepts and knowledge (Arends, 2012).

The CS-PBL model can train students in how to think by focusing attention and building relationships between students to produce valid information and solutions (Amanda et al., 2022). Based on these findings, CS-PBL is proposed as a solution. This study aims to determine the correlation between science literacy and concept mastery with problem solving skills through the implementation of the CS-PBL model. The findings of this study are expected to be used as a reference for institutions that adopt and implement learning models to develop the skills needed in the 21st century.

Method

Research Design

This research used a correlational quantitative design conducted at State Senior High School (SSHS) 6 of Malang, Indonesia. The sample consisted of 34 students of eleventh class who took Biology as an elective subject. The variables studied were science literacy and concept mastery as predictor variables, while problem-solving skills were used as criterion variables. The research was conducted on Biology subject of eleventh class (Phase F) on the learning outcome (CP) of human respiration system. The implementation of CS-PBL was conducted in six meetings during July to August 2024. After a series of learning, the students were conducted an essay test to evaluate the science literacy, concept mastery, and problem-solving skills. The CS-PBL learning process was carried out in seven step (Amanda et al., 2022), as in Table 1.

Table 1. CS-PBL model syntax

The Steps	Student Activity
1. Problem orientation	Students use their worksheets to investigate the presented phenomenon.
2. Organizing students to learn	Students collect data about the current issue from a variety of sources.
3. Identifying required disciplines and concepts	Students make a mind map to connect or link the primary problem with necessary disciplines after identifying the disciplines and concepts needed to solve the problem.
4. Investigation and clarification to a team of expert	Students conduct research to collect data and get explanations from a team of experts.
5. Analyzing and connecting information and data	Students use a mind map to link and evaluate the facts they have collected in order to identify the problem's root cause and produce suggestions for solutions.
6. Presentation of problem-solving ideas	Students submit suggestions for overcoming problems through presentations, followed by a discussion.
7. Evaluation	Students evaluate and reflect on ideas and the problem-solving probe

Research Instruments

To measure students' learning achievement, we used five questions each on scientific literacy, concept mastery, and problem-solving skills. The instrument has been validated through Pearson's product moment test and reliability test through Cronbach's-Alpha test. The results of the Pearson product moment validity test showed that all items were valid because all count> r_{table} values. The r_{table} value with N = 20 is 0.444 and the r_{count} of all items is in the range of 0.563 to 0.816. The results of the reliability test using Cronbach's Alpha show a value of 0.731> 0.600 which can be interpreted as reliable. The science literacy test consists of three indicators of science literacy: (1) explain phenomena scientifically, (2) design and evaluate scientific enquiry, and (3) interpret data and evidence scientifically (OECD, 2016). Concept mastery consists of six indicators: remember, understand, apply, analyze evaluate, and create (Krathwohl, 2002). Assessment of problem solving skills consists of four indicators: understanding the problem, developing a plan, implementing the plan, and reviewing the results obtained (Pólya, 2004).

Data Collection and Data Analysis

Data on science literacy, concept mastery, and problem solving skills were obtained from student test results. The test answers were assessed based on predetermined indicators and then analyzed using multiple regression analysis supported by SPSS for Windows and conducted at the 5% significance level. Normality and homogeneity tests were conducted using Kolmogorov-Smirnov and Levene's tests before conducting multiple regression analysis.

Results and Discussion

The results of the normality test using the Kolmogorov-Smirnov test in Table 2 show a sig value of 0.200 > 0.05 which means the data is normally distributed. The results of the homogeneity test using Levene's test show homogeneous data results due to the sig value is 0.814 (>0.05). The homogeneity test results refer to Table 3.

Table 2. Normality test result using the Kolmogorov-Smirnov

	Kolmogorov-Smirnov Test	
	N	Asymp. Sig. (2-tailed)[c]
Unstandardized Residual	34	0.200[d]

Table 3. Homogeneity test results using Levene's

Levene's Test	
Levene Statistic	Sig.
3.274	0.815

The results of ANOVA analysis to calculate the significance of the correlation between science literacy and concept mastery with problem solving skills are presented in Table 4. The calculation results show a significant value of 0.006 <0.050, which means that science literacy and concept mastery have a significant relationship to problem-solving skills through the application of the CS-PBL learning model.

Table 4. ANOVA test results

ANOVA [a]						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.257	2	25.129	6.003	.006[b]
	Residual	129.772	31	4.186		
	Total	180.029	33			

a. Dependent Variable: Problem solving skills
b. Predictors: (Constant), Concept understanding, Science literacy

Table 5 summarizes the correlation results of whether there is a relationship between all the predictors and the criterion. The R column in Table 5 is the multiple correlation coefficient, while R square is the determination value.

Table 5. Summary of correlation results

Model Summary [b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.528[a]	.279	.233	2.046

a. Predictors: (Constant), Concept understanding, Science literacy
b. Dependent Variable: Problem solving skills

The regression test results in Table 5 show that the correlation coefficient (R) is 0.528 with an R square value of 0.279. This means that science literacy and concept mastery contribute 27.9% to problem solving skills, while 12.1% is influenced by other factors. A summary of the relative and effective contributions of the predictor variables to the criterion variable can be seen in Table 6.

Table 6. Summary of relative and effective contributions of predictor variables to criterion variables

Variable	Relative contribution (%)	Effective contribution (%)
Science literacy	72,1	20,2
Concept understanding	27,9	7,8
Total	100	28

Table 6 shows that science literacy has a relative contribution to problem solving of 72.1%, while concept mastery is 27.9%. Science literacy and concept mastery effectively contributed to problem solving skills by 20.2% and 7.8%, with a total effective contribution of 28.0%. The regression coefficient results to show how much the measured variables contribute to problem solving skills are shown in Table 7.

Table 7. Regression coefficient results

Coefficients [a]						
Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
		B	Std. Error			
1	(Constant)	44.537	12.444	.412	3.579	.001
	Science literacy (X1)	.299	.119	4.186	2.519	.017
	Concept understanding (X2)	.182	.139	.214	1.310	.200

a. Dependent Variable: Problem solving skills

Table 7 shows that the equation of the multiple regression line between science literacy and concept mastery on students' problem solving skills through the application of the CS-PBL model is Y = 0.299 X1 + 0.182 X2 + 44.54. The number 0.299 in X1 is the value of the regression coefficient of the science literacy variable on problem solving skills. This means that when the value of scientific literacy increases by one unit, the value of problem solving skills will increase by 0.299. The number 0.182 in X2 is the regression coefficient of the concept mastery variable on problem solving ability. This means that when the value of concept mastery increases by one unit, the value of problem solving skills will Increase by 0.182.

The results of this research showed that science literacy and concept mastery contributed to students' problem solving skills after the application of the CS-PBL model. Science literacy and concept understanding improve problem solving skills by providing students with a strong framework for systematic and analytical thinking (Ramadhan & Mardin, 2023). Science literacy improves problem solving skills by providing a strong knowledge base, effective analytical methods, and evidence-based approaches to identify, analyze, and solve problems (Kelp et al., 2023). Good mastery of science literacy allows students to face challenges and find innovative and sustainable solutions (Sari et al., 2024). Through concept understanding, students can connect various aspects of science and apply them in real situations (Daloos & Paderna, 2023). Concept understanding with the application of Bloom's taxonomy helps classify levels of understanding, which allows educators to design learning activities to encourage the development of higher order thinking skills necessary for effective problem solving (Gultepe, 2016).

The application of the CS-PBL model can effectively improve students' science literacy and concept mastery which also affects students' problem solving skills. In this era of globalization, students face complex problems in real life that require several disciplines, reciprocal relationships and dependencies between each variable, and various levels of analysis to solve them (Ji et al., 2017). Learning models that use real-world situations in their learning have the potential to encourage students scientific thinking and cognitive abilities (Boon et al., 2019; Fiore et al., 2018). Students can actively build new knowledge by analyzing real-world challenges (Osman et al., 2020).

The multiple regression equation in Table 7 shows a positive equation, which means that there is a relationship between science literacy and concept mastery on problem solving skills in a positive direction. During the learning process, if students' science literacy and concept mastery increase, then students' problem solving skills will also increase. In line with several previous studies that show that individuals with high academic ability tend to have good mastery of science literacy which can affect students' problem solving skills (Amanda et al., 2023b; Anggraeni et al., 2023; Sari et al., 2024). This means that high-ability students show high understanding in applying science literacy, which is an important aspect of problem-solving skills (Mawaddah et al., 2021).

Problems in the human respiration system are closely related to complex and unstructured health problems (Kumlin et al., 2020). Abstract problems are actual situations known as authentic problems and reflect real challenges faced by society (Horvat et al., 2016). Solving abstract problems requires a

high level of understanding and reasoning and involves various relevant disciplines because it has several aspects that affect each other (Merone et al., 2020). Mastery of science literacy and problem-solving skills is needed to solve problems with a scientific and systematic perspective (Barak & Assal, 2018).

Problem-solving skills result from mastering complex concepts in terms of intellectual capacity (Batlolona et al., 2018; Mitchell & Walinga, 2017). Students usually need strong concept understanding to solve complex problems (Glazewski & Ertmer, 2020). According to research by Fries et al. (2021), students who have deep concept mastery can filter information when creating solutions and examine related information to understand the difficulties they face. Concept mastery is the basis of higher-order thinking ability to empower problem-solving skills (Cansoy & Emin, 2017). Concept mastery and science literacy are inseparable because both focus on students' thinking skills to solve a problem (Sari et al., 2024).

The CS-PBL learning model focuses on multidisciplinary and trans-disciplinary research that combines components of biology, physics, socio-economics, mathematics, engineering, and humanities to answer complex problems (Amanda et al., 2023a). The CS-PBL model invites students to identify, analyze and find solutions to the problems faced (Amanda et al., 2022). This analysis activity can help students to develop science literacy by looking at the problem holistically and finding solutions with scientific considerations (Heinrich & Kupers, 2019; Jacobson et al., 2019). Analyzing activities will also make students accustomed to analyzing the problems faced and help students develop problem solving skills. Students also connect information with the results of investigations with the aim of producing strong and valid concepts so that the level of understanding of students' concepts increases (Valladares, 2021). CS-PBL learning focuses on finding solutions that require integration of concepts from various relevant disciplines (Amanda et al., 2023a). Students are invited to connect science to understand living systems and help deal with problems in nature (Lendeon & Poluakan, 2022).

The CS-PBL learning model facilitates students' mastery of thinking skills and problem-solving skills that also help them in acquiring key concepts from the subject matter (Amanda et al., 2022). The 21st century education focuses on problem-solving learning to train students' thinking and social skills (Fiore et al., 2018). The 21st century education system It is expected to produce human resources who are able to think critically, creatively and innovatively. as well as being able to communicate and collaborate to solve problems (Graesser et al., 2019). The results of this discussion show that application of the CS-PBL model can empower problem-solving skills that are influenced by students' science literacy and concept understanding.

Conclusion

The results of the study can be concluded that there is a positive and significant relationship between science literacy and concept mastery with problem solving skills. After applying the CS-PBL learning model, science literacy has a greater relative contribution to problem solving which is 72.1%, while concept mastery is only 27.9%. Learning that can empower science literacy, concept understanding, and problem solving skills is by accommodating their abilities in problem-based learning such as the CS-PBL model.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

I. N. Sari: conducting the research, collecting data, and writing original article; **S. Mahanal,** and **S. Prabaningtyas:** supervising the research, revision, and advisor.

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