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Investigating the Relationship Between Self-Regulation, Environmental Literacy, and Students' Problem-Solving Skills in Environmental Pollution

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Abstract

The environmental issues that occur could be addressed, one of which was through environmental education applied to the concept of biology regarding environmental pollution. This research aimed to determine the relationship between self-regulation and environmental literacy with problem-solving abilities regarding environmental pollution among high school students. The research method used was descriptive with a cross-sectional survey technique. The sample of this study consists of 150 high school students. The instruments used in this study were tests and questionnaires. The results of the hypothesis test showed a positive relationship between self-regulation and environmental literacy with problem-solving abilities in addressing environmental pollution, both partially and collectively. Based on the research findings, the ability to solve environmental pollution issues among high school students could be improved through self-regulation and environmental literacy. The relationship between self-regulation and environmental literacy collectively contributes to problem-solving ability, so if self-regulation and environmental literacy were high, it was expected that the problem-solving ability regarding environmental pollution among high school students would also improve, thereby providing beneficial actions in the form of prevention and resolution of contemporary environmental problems.

Keywords: Self-regulation, environmental literacy, problem-solving

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INTRODUCTION

Environmental issues, including pollution, are among the global challenges that must be urgently addressed in the 21st century. These issues require strategic and sustainable solutions to protect ecosystems and ensure the well-being of future generations. The increasing impact of human activities on ecosystems demands that individuals possess the ability to understand, analyse, and solve environmental problems effectively. One of the ways to address environmental problems wisely is through environmental education. Environmental education is almost integrated into every subject in schools and can be applied to biological concepts that require problem-solving skills.

Students are directed to understand and become aware of current environmental issues to develop the expected problem-solving skills (Prastiwi *et al*., 2019). Students' ability to think more complexly and their reasoning and problem-solving skills represent fundamental cognitive abilities (Sopamena *et al*., 2018). Several theories from psychologists relate to cognitive development, one of which is Jean Piaget's theory. Piaget stated that human cognitive abilities consist of four stages: the sensorimotor stage (0-2 years), the preoperational stage (2-7 years), the concrete operational stage (7-11 years), and the formal operational stage (11-15 years and above) (Dahar, 2011).

In Indonesia, the formal operational stage occurs during high school. Reasoning at this stage is characterised by the ability to think about abstract ideas, organise thoughts, and reason about what might happen next. At the formal operational stage, individuals can perform hypothetico-deductive reasoning, meaning they can formulate hypotheses (best guesses) to solve problems and reach systematic conclusions (Azzahra *et al*., 2023). Previous research shows that problem-solving skills, particularly in biology learning on environmental pollution topics among high school students, are still low (Chaerunisa & Pitorini, 2022). According to Wardhani and Rumiati (2011), Indonesian students are generally undertrained in solving problems requiring reasoning, resulting in an inability to develop strong analytical skills effectively.

All the challenges students face in achieving success in education require good self-regulation. Problem-solving skills are closely related to self-regulated learning among students. Self-regulation in learning promotes students' ability to achieve effective problem-solving skills (Zimmerman & Schunk, 1989). Self-regulated learning is defined as students taking responsibility for their learning, which is an essential component for success in education (Dettori & Persico, 2011). Students with good self-regulation can identify their preferred learning styles, recognise what is easy and difficult for them, and leverage their strengths or advantages (Woolfolk, 2008). Based on this, students will find it easier to absorb knowledge and implement it in solving problems while considering environmental balance (Mirmoadi & Satwika, 2022).

Research by Khoerunnisa *et al*. (2021) and Theresya et al. (2018) indicates that students generally exhibit low levels of self-regulated learning. This affects their task performance, leading to unsatisfactory results and difficulties in managing their study time. These challenges subsequently impact the learning process provided to them. The learning process guides students to understand and become aware of environmental issues, forming the expected environmental problem-solving skills. Problem-solving skills are also related to environmental literacy. Environmental literacy is defined as the knowledge, competencies, and actions that lead to a healthier and more sustainable society, influenced by social factors and aligned with social and personal norms. Environmental literacy helps students evaluate different perspectives in solving problems (Fang, 2020).

Research by Arofah & Pujilestari (2020) and Ilma & Wulandari (2023) states that students' attitudes toward maintaining the school environment have become a focal point because many students still leave trash in inappropriate places. This indicates that students' environmental literacy, particularly in terms of attitudes and behaviours, is still relatively low. Research by Santoso *et al*. (2021) shows that environmental literacy in terms of environmental awareness and responsible environmental behaviour achieved high scores, while ecological knowledge and cognitive skills scored low. Students reported difficulty analysing environmental problems and complained about unfamiliar words when completing the environmental literacy questionnaire.

The highest level of environmental engagement can be achieved when the components of knowledge, environmental attitudes, and environmental behaviour integrate and result in environmental action implementation (Adler *et al*., 2016). Environmental literacy skills can be improved through appropriate self-regulation (Sugiyarti *et al*., 2020). As part of society, students must be equipped with environmental literacy skills to become future generations and agents of change capable of solving environmental problems (Kusumaningrum, 2018). Based on the above explanation, problem-solving skills, self-regulation, and environmental literacy are interrelated concepts. Empirical studies in the literature reveal relationships between these concepts. Research by Maksum *et al*. (2021) using a survey method with path analysis found that self-regulation affects problem-solving skills. Self-regulated students enhance their ability to solve problems systematically, logically, more orderly, and thoroughly.

Research by Yeh *et al*. (2022), using a mixed-method approach, showed that students with higher environmental literacy scores could apply environmental problem-solving strategies, analyse solutions to environmental problems optimally, and propose various plans for addressing environmental issues. This study differs from previous research in linking self-regulation and environmental literacy simultaneously with environmental pollution problem-solving skills. Furthermore, this study was designed as descriptive research using a cross-sectional survey technique.

This research is important to identify the variables related to students' problem-solving skills and the predictive power of these variables. In this study, self-regulation and environmental literacy variables are hypothesised to facilitate problem-solving skills, as stated in the literature. Based on the above explanation, research is needed to describe the relationship between self-regulation, environmental literacy, and problem-solving skills in environmental pollution.

METHODS

This research employed a descriptive method with a cross-sectional survey technique. The population and sample were determined using a multi-stage random sampling technique. The steps taken included selecting the research population, which comprised all public senior high schools (SMA Negeri) in Tangerang Regency, and choosing SMA Negeri 6 Tangerang Regency using purposive sampling. Subsequently, 11th-grade science students (XI MIPA) were selected through purposive sampling. A total of 240 students from XI MIPA classes participated, and using Slovin's formula, a sample size of 150 students was determined and selected through simple random sampling.

The instrument for measuring environmental pollution problem-solving skills was an essay-based test adapted from the OECD (2012). This instrument comprised dimensions such as understanding the problem, representing and formulating the problem, planning and implementing problem-solving, and reviewing solutions. Self-regulation was measured using a non-test instrument in the form of a questionnaire adapted from Erdogan and Senemoglu (2016). The self-regulation instrument consisted of dimensions such as pre-learning strategies, during-learning strategies, post-learning strategies, and motivation. Environmental literacy was measured using a combination of test instruments (multiple-choice) and non-test questionnaires adapted from McBeth *et al*. (2008). The environmental literacy instrument included dimensions such as environmental knowledge, cognitive abilities, attitudes towards the environment, and environmental behaviour.

Hypothesis testing in this research was conducted using regression and correlation analysis techniques. Regression analysis was used to determine the regression model among the connected variables. Before conducting regression analysis, classical assumption tests were performed, including tests for normality, homogeneity, linearity, multicollinearity, heteroscedasticity, and autocorrelation. After the classical assumption tests, a multiple linear regression model was created as follows: $\hat{Y} = a + b_1X_1 + b_2X_2 + e$.

Correlation analysis was used to determine whether there were relationships between variables and the strength of those relationships. Multiple linear correlation analysis involved three correlation coefficients: multiple determination coefficient (R^2), multiple correlation coefficient (R_{x1x2}), and partial correlation coefficient. Significance testing for multiple correlation and partial correlation analyses was conducted using the F-test.

RESULTS & DISCUSSION

Results

The results of the study provide descriptive statistics for the key variables analysed. For self-regulation (X_1), the highest score recorded was 97, the lowest score was 58, and the mean score was 72.09. In the case of environmental literacy (X_2), the highest score was 93, the lowest score was 54, and the mean score was 76.82. Meanwhile, for problem-solving skills in environmental pollution (Y), the highest score was 99, the lowest score was 63, and the mean score was 86.23. The classical assumption tests are summarised in Table 1.

Table 1. Summary of Classical Assumption Tests

No.	Classical Assumption Tests	Conclusion
1	Normality Test (Kolmogorov-Smirnov Test)	Data distribution is normal
2	Homogeneity Test (Bartlett's Test)	Homoscedasticity assumption met
3	Heteroscedasticity Test (Tolerance and VIF)	No heteroskedastisitas detected
4	Multicollinearity Test (Scatterplots)	No multicollinearity detected
5	Autocorrelation Test (Durbin-Watson Test)	No autocorrelation detected

Based on the results of the study, the first hypothesis posits a positive relationship between self-regulation (X_1) and problem-solving skills for environmental pollution. From the linear regression test using SPSS, the results showed ($F_{count} > F_{table(0.05;148)}$), specifically 19.653 > 3.91. This indicates that the null hypothesis (H_0) is rejected, and the regression model is significant. The calculated regression model for self-regulation and problem-solving skills yielded a regression constant a = 62.074 and regression coefficient b = 0.335. The resulting regression equation is $\hat{Y} = 62.074 + 0.335X_1$, where X_1 is self-regulation, and Y is problem-solving skills for environmental pollution. The linearity test revealed $F_{count} = 0.880 < F_{table(0.05:68/80)} = 1.47$, confirming that the regression model $\hat{Y} = 62.074 + 0.335X_1$ is linear at a significance level $\alpha = 0.05$. This regression equation implies that for every one-point increase in self-regulation, problem-solving skills increase by 0.335 points, given a constant of 62.074.

The strength of the relationship between self-regulation and problem-solving skills is indicated by a correlation coefficient of 0.342. The coefficient of determination (R^2) for self-regulation and problem-solving skills is 11.7%, meaning self-regulation contributes 11.7% to problem-solving skills through the model $\hat{Y} = 62.074 + 0.335X_1$ at $\alpha = 0.05$. The significance of the correlation coefficient was tested using a t-test, yielding $t_{count} > t_{table(0.05;148)}$, specifically 4.43 > 1.98, indicating a significant correlation (r_{x1y}). Thus, the null hypothesis is rejected, confirming a positive relationship between self-regulation (X_1) and problem-solving skills (Y), with a correlation strength categorised as weak. This suggests that higher self-regulation correlates with improved problem-solving skills for environmental pollution among students.

Partial correlation analysis of self-regulation and problem-solving skills, controlling for environmental literacy, yielded a partial correlation coefficient of 0.247, with $F_{count} = 9.55 > F_{table(0.05;2;147)} = 3.05$. This indicates that the partial correlation between self-regulation (X_1) and problem-solving skills (Y) with environmental literacy (X_2) as a control variable is statistically significant.

The second hypothesis posits a positive relationship between environmental literacy (X_2) and problem-solving skills for environmental pollution. From the linear regression test using SPSS, the results showed $F_{count} > F_{table(0.05;148)}$, specifically 14.202 > 3.91. This indicates that H_0 is rejected, and the regression model is significant. The regression model for environmental literacy and problem-solving skills produced a regression constant of 63.554 and a regression coefficient of b = 0.295. The resulting regression equation is $\hat{Y} = 63.554 + 0.295X_2$, where X_2 is environmental literacy, and Y is problem-solving skills for environmental pollution. The linearity test revealed $F_{count} = 1.339 < F_{table(0.05:31/117)} = 1.55$, confirming that the regression model $\hat{Y} = 63.554 + 0.295X_2$ is linear at $\alpha = 0.05$. This regression equation implies that for every one-point increase in environmental literacy, problem-solving skills increase by 0.295 points, given a constant of 63.554.

The strength of the relationship between environmental literacy and problem-solving skills is indicated by a correlation coefficient of 0.296. The coefficient of determination (R^2) for environmental literacy and problem-solving skills is 8.8%, meaning environmental literacy contributes 8.8% to problem-solving skills through the model $\hat{Y} = 63.554 + 0.295X_2$ at $\alpha = 0.05$. The significance of the correlation coefficient was tested using a t-test, yielding $t_{count} > t_{table\ (0.05;148)}$, specifically 3.77 > 1.98, indicating a significant correlation (r_{x2y}). Thus, H_0 is rejected, confirming a positive relationship between environmental literacy (X_2) and problem-solving skills (Y), with a correlation strength categorised as weak. This suggests that higher environmental literacy correlates with improved problem-solving skills for environmental pollution among students.

Partial correlation analysis of environmental literacy and problem-solving skills, controlling for self-regulation, yielded a partial correlation coefficient of 0.247, with $F_{count} = 4.48 > F_{table(0.05;2;147)} = 3.05$. This indicates that the partial correlation between environmental literacy (X_2) and problem-solving skills (Y) with self-regulation (X_1) as a control variable is statistically significant.

The third hypothesis posits a positive joint relationship between self-regulation (X_1) and environmental literacy (X_2) with problem-solving skills for environmental pollution (Y). From the multiple regression and correlation analysis using SPSS, the results showed Fcount> $F_{table(0.05;147)}$, specifically 12.303 > 3.05. This indicates that H_0 is rejected, confirming a significant and positive joint relationship between the independent variables and problem-solving skills. The regression model yielded a constant a = 53.859, and regression coefficients $b_1 = 0.285$ and $b_2 = 0.180$, resulting in the regression equation $\hat{Y} = 53.859 + 0.285X_1 + 0.180X_2$, where X_1 represents self-regulation, X_2 represents environmental literacy, and Y represents problem-solving skills for environmental pollution.

The strength of the relationship among the variables is indicated by a correlation coefficient of 0.379, with $F_{count} = 12.303 > F_{table(0.05;157)} = 3.05$, confirming that the joint relationship is statistically significant. Based on the coefficient of determination (R^2), self-regulation and environmental literacy collectively explain 14.3% of the variance in problem-solving skills through the multiple regression model $\hat{Y} = 53.859 + 0.285X_1 + 0.180X_2$. This underscores the positive relationship between self-regulation and environmental literacy, individually and jointly, with problem-solving skills for environmental pollution. However, with a correlation coefficient of 0.379, the relationship strength is categorised as weak.

Discussion

Based on the first hypothesis test, the research results indicate a positive relationship between self-regulation (X_1) and environmental pollution problem-solving skills (Y). This positive relationship signifies that the more positive the students' self-regulation, the higher their problem-solving abilities. Although a positive relationship exists between self-regulation and problem-solving skills, the research findings show that the strength of the relationship between these variables is weak.

The weak correlation may be attributed to the motivational dimension of self-regulation, which scored the lowest among the four dimensions with an average score of 69.65. Motivation, as an intrinsic driver, determines the extent to which students are willing to engage in complex cognitive activities such as understanding, planning, and solving environmental problems. According to Deci and Ryan (2000), intrinsic motivation is critical for sustained engagement in learning tasks. Students with high self-efficacy, a key component of motivation, are more likely to demonstrate perseverance and creativity in tackling environmental challenges (Bandura, 1997). Conversely, low self-efficacy may undermine students’ confidence and engagement, as supported by previous research (Sadi & Dagyar, 2013; Ning & Downing, 2010). Motivation also involves task value, where students are more likely to engage deeply when they perceive the task as relevant to their lives (Eccles & Wigfield, 2002). Thus, fostering connections between environmental problems and students’ daily experiences could enhance their motivation to solve such issues.

Pre-learning strategies, encompassing planning, time management, and organisation, are another critical aspect of self-regulation that impacts problem-solving skills. This dimension scored an average of 71.13, indicating that while some students utilise these strategies, others may lack the necessary skills to prepare effectively. Planning involves setting clear objectives and mapping out steps to achieve them, which Zimmerman (2002) describes as foundational for success in complex cognitive tasks. Additionally, time management and environmental organisation help create optimal learning conditions, allowing students to concentrate and focus on solving environmental problems. The relatively low performance in pre-learning strategies suggests a need for targeted interventions to strengthen these foundational skills.

During-learning strategies, which include monitoring progress, seeking assistance, and applying memory techniques, scored higher than pre-learning strategies, with an average of 72.94. These strategies help students stay focused on their learning goals and make adjustments as needed. Schunk (2012) highlights the importance of self-monitoring in identifying strengths and weaknesses during the learning process, which is crucial for iteratively improving problem-solving approaches. Seeking help, whether from peers or teachers, also plays a vital role in resolving learning obstacles and advancing understanding. However, the findings suggest that some students still face challenges in consistently applying these strategies, which may limit their problem-solving effectiveness.

Post-learning strategies, including self-evaluation and the application of consequences, demonstrated the highest average score at 76.97. These strategies enable students to reflect on their learning outcomes, assess the effectiveness of their solutions, and identify areas for improvement. Self-evaluation fosters critical thinking and encourages students to refine their approaches to solving environmental problems (Schunk & Zimmerman, 2007). Additionally, implementing consequences, such as rewarding achievements or addressing gaps in performance, reinforces commitment to learning and problem-solving. Deci and Ryan (2000) argue that positive reinforcement, such as recognition or personal satisfaction, enhances intrinsic motivation and promotes continuous improvement.

Based on the second hypothesis test, the research results indicate a positive relationship between environmental literacy (X_2) and environmental pollution problem-solving skills (Y). This positive relationship means that the more positive the students' environmental literacy, the higher their problem-solving abilities. Students can enhance their environmental problem-solving skills when supported by strong environmental literacy. Although there is a positive relationship between environmental literacy (X_2) and environmental pollution problem-solving skills (Y), the research findings show that the strength of the relationship between these variables is weak.

However, several factors may limit students' ecological knowledge, including their age and limited interaction with natural environments (Pitman *et al*., 2016). For instance, younger students, often with fewer opportunities for experiential learning, may struggle to internalise complex ecological relationships. Research indicates that ecological literacy tends to improve with age and accumulated experiences, as older individuals are more likely to have had diverse interactions with environmental contexts (Prastiwi *et al*., 2020). Direct and sustained exposure to environmental education is therefore crucial. Integrating ecological concepts into formal curricula, complemented by outdoor experiential learning activities, can help students build a stronger knowledge base. By observing ecosystems directly and participating in conservation projects, students are more likely to develop an intuitive understanding of ecological dynamics. This, in turn, equips them to evaluate environmental problems more effectively and propose solutions grounded in scientific principles.

The cognitive skills dimension of environmental literacy, with an average score of 76.52, indicates that students possess a moderate capacity to analyse environmental issues and generate appropriate solutions. Cognitive skills involve the ability to identify problems, synthesise information, and apply critical thinking to devise effective interventions (Goldman *et al*., 2020). These skills bridge the gap between theoretical knowledge and practical application, enabling students to address environmental challenges systematically. Project-based learning approaches have been shown to significantly enhance cognitive skills by immersing students in real-world environmental scenarios (Hung, 2013; Jonassen, 2011). For example, students tasked with designing a waste management program for their school must analyse data, evaluate potential strategies, and implement their chosen solution. Such hands-on experiences foster higher-order thinking and problem-solving abilities, which are critical for tackling the complexities of environmental pollution. Cognitive skills are further strengthened when students are encouraged to collaborate, as teamwork exposes them to diverse perspectives and problem-solving strategies.

The attitudes dimension scored 71.79, reflecting students' readiness to internalise sustainability values and their willingness to engage in environmental conservation. Positive attitudes towards the environment serve as a motivational foundation for pro-environmental behaviour. Students with favourable attitudes are more likely to take active roles in identifying, analysing, and addressing environmental problems (Hines *et al*., 2010). Such attitudes often stem from an awareness of environmental challenges and a belief in the importance of sustainable practices. However, attitudes alone may not always translate into action, as noted by Kollmuss and Agyeman (2002). Bridging the gap between attitudes and behaviour requires educational strategies that emphasise the real-world relevance of environmental issues. For instance, incorporating case studies of successful sustainability initiatives into the curriculum can inspire students to view their efforts as part of a larger, impactful movement. Attitudes can also be bolstered by connecting classroom learning with community-based projects, allowing students to witness the tangible benefits of environmental stewardship.

Pro-environmental behaviour emerged as the strongest dimension of environmental literacy, with a score of 83.38. This dimension encompasses actions taken to mitigate environmental problems, such as recycling, conserving energy, and participating in ecological restoration efforts (Stern *et al*., 2008). Such behaviours indicate students' ability to operationalise their knowledge and attitudes, translating these into concrete, impactful actions. Behavioural engagement often stems from both intrinsic motivation and external reinforcement. Students who see the immediate results of their actions, such as a cleaner schoolyard or reduced waste, are more likely to sustain their commitment to environmental practices. Moreover, the integration of behavioural education into school programs, such as organising recycling drives or tree-planting campaigns, not only reinforces students' skills but also cultivates a sense of community responsibility. Practical experiences play a vital role in enhancing pro-environmental behaviours. Activities like monitoring local water quality, managing waste segregation systems, or participating in urban gardening initiatives provide students with the opportunity to apply their knowledge and skills in real-life contexts. These activities also encourage reflection, enabling students to evaluate the effectiveness of their actions and identify areas for improvement (Kollmuss & Agyeman, 2002).

Based on the third hypothesis test, the research results indicate a positive relationship between self-regulation (X_1) and environmental literacy (X_2), together with environmental pollution problem-solving skills (Y). These findings demonstrate that the higher the self-regulation values, supported by environmental literacy, the higher the students' environmental pollution problem-solving skills.

Despite the positive relationship between self-regulation, environmental literacy, and problem-solving skills, the strength of the correlation is weak. This may be attributed to the characteristics of the students. Self-regulation, as the ability to manage the learning process, plays a critical role in supporting problem-solving. However, some aspects of self-regulation, such as learning motivation and learning strategies, are not consistently applied by students. Pintrich (2004) emphasised that the effectiveness of self-regulation is heavily dependent on strong intrinsic motivation, which serves as the primary driver in implementing self-regulation strategies. A low score on the motivation dimension suggests that students may not be fully motivated to utilise self-regulation during the problem-solving process.

Similarly, while environmental literacy shows a positive correlation, its contribution to problem-solving skills may also be weak. Environmental literacy involves not only basic knowledge of environmental issues but also a deep understanding of methods to address relevant problems. According to Stern *et al*. (2008), environmental literacy requires integrating conceptual knowledge with practical experience to exert a significant impact on action. If students' environmental literacy is limited to theoretical aspects without being supported by real-life experiences in addressing environmental issues, its impact on problem-solving skills may not be substantial.

Another factor to consider is the influence of supportive learning environments. Research by Dinsmore and Alexander (2012) highlights that the presence of a supportive learning environment strongly influences the effectiveness of self-regulation and environmental literacy in fostering problem-solving skills. Furthermore, if students are not engaged in problem-based learning activities, the potential of environmental literacy to support self-regulation and problem-solving skills may remain underdeveloped.

Additionally, the weak relationship may also be due to differences in students' characteristics when applying self-regulation and environmental literacy. Zimmerman (2002) noted that self-regulation is a skill that develops gradually and is highly dependent on experience and context. Similarly, Stern *et al*. (2008) argue that students' cultural and social backgrounds influence environmental literacy. In this study, significant variations in students' initial experience and knowledge levels may contribute to the weak relationship among the variables examined.

These results indicate that a more comprehensive educational approach is needed to strengthen the relationship between self-regulation, environmental literacy, and problem-solving skills. Educational interventions designed to enhance intrinsic motivation, such as contextual and collaborative learning, can help students develop more effective self-regulation (Schunk & Zimmerman, 2007). Additionally, implementing project-based approaches that actively involve students in addressing real-world environmental problems can elevate their environmental literacy to a more practical level (Jonassen, 2011). Although the relationships found in this study are weak, more targeted strategies can enhance the contribution of self-regulation and environmental literacy to problem-solving skills.

Compared to previous studies, there are notable differences in the findings. While earlier research mainly focused on individual relationships, this study explores the joint relationship between self-regulation, environmental literacy, and problem-solving skills in the context of environmental pollution. Despite these differences, the overall findings confirm that self-regulation and environmental literacy are interconnected with problem-solving abilities.

Problem-solving is a vital cognitive process, essential in daily life, workplaces, and educational settings. It involves closing the gap between the initial state and the goal state (Mayer, 1992; Jonassen, 2011; Schunk, 2012). Prior research has shown that self-regulation in learning (self-regulated learning) is crucial for effective problem-solving (Baars *et al.*, 2017). Self-regulation enables students to manage their learning processes, including setting goals, monitoring progress, and adjusting strategies as needed. This ability is critical for addressing complex problems like environmental pollution. Students with strong self-regulation can maintain focus, overcome cognitive and emotional challenges, and develop effective solutions to environmental issues (Baumeister *et al.*, 2007).

Environmental pollution problem-solving skills improve when students exhibit both self-regulation and environmental literacy, compared to possessing only one of these skills. Together, self-regulation and environmental literacy support students in understanding environmental problems, ultimately leading to more effective solutions that enhance their problem-solving abilities. These skills, once practised in schools, are likely to transfer to real-world contexts, contributing to better environmental conditions in students' communities.

Environmental literacy provides students with a deep understanding of ecological systems, the relationship between humans and the environment, and the analytical skills necessary to address environmental challenges. With strong environmental literacy, students can identify the root causes of problems, evaluate the impact of pollution, and design relevant interventions. Additionally, this literacy promotes a holistic perspective, which is crucial for creating sustainable solutions (Deci & Ryan, 2000).

Self-regulation and environmental literacy are mutually reinforcing in shaping students' ability to solve environmental problems. Self-regulation enables students to manage their thought processes, including designing problem-solving strategies, monitoring progress, and evaluating the effectiveness of actions taken. Environmental literacy, on the other hand, provides the relevant knowledge and skills needed to understand and address environmental challenges effectively (Baumeister *et al.*, 2007; Deci & Ryan, 2000).

Self-regulation serves as a cognitive foundation that helps students stay focused and directed, while environmental literacy offers the specific context necessary to analyse and solve problems. For example, students with strong self-regulation can systematically identify steps to address pollution problems, while environmental literacy allows them to understand the ecological impacts and underlying factors of such pollution (Gifford & Nilsson, 2014; Kollmuss & Agyeman, 2002).

This relationship becomes increasingly critical when addressing complex environmental challenges, such as water, air, or soil pollution, which require interdisciplinary approaches. Self-regulation supports students in managing high cognitive demands, while environmental literacy deepens their understanding of ecosystem dynamics and the interplay between human and environmental factors. The interaction between these skills creates opportunities for students to design more innovative and sustainable solutions (McBride *et al*., 2013; Pintrich, 2004).

Furthermore, students with strong self-regulation are more likely to leverage their environmental literacy to its fullest potential. This motivation is supported by the ability to set clear learning objectives, such as deepening their understanding of specific environmental issues or developing more effective problem-solving strategies. Environmental literacy, in turn, provides students with a clear framework to identify priority issues and develop relevant solutions (Vansteenkiste *et al*., 2010; Schunk & Zimmerman, 2012).

In conclusion, self-regulation and environmental literacy are not isolated abilities but complementary skills that enable learners to address environmental challenges strategically and responsibly. Their interaction not only strengthens individual capabilities but also contributes significantly to creating a more environmentally conscious society capable of tackling global challenges (McBride *et al*., 2013; Schunk & Zimmerman, 2012). The positive correlation between self-regulation, environmental literacy, and problem-solving skills underscores their interconnectedness, offering valuable insights for enhancing students' environmental problem-solving capabilities.

CONCLUSION

Based on the research findings, it can be concluded that there is a positive relationship between self-regulation and environmental pollution problem-solving skills among high school students; there is a positive relationship between environmental literacy and environmental pollution problem-solving skills among high school students, and there is a positive relationship between self-regulation and environmental literacy together with environmental pollution problem-solving skills among high school students.

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