**Paedagoria : Jurnal Kajian, Penelitian dan Pengembangan Kependidikan**
http://journal.ummat.ac.id/index.php/paedagoria
Prefix DOI: 10.31764

ISSN 2086-6356 (Print)
ISSN 2614-3674 (Online)
Vol. 15, No. 4, Oktober, hal.436-446

# ENVIRONMENTAL PROBLEM-BASED LEARNING BOOTS SKILLS IN RIVER PROBLEM SOLVING AND ECOLOGICAL AWARENESS

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**INFO ARTIKEL**

***Riwayat Artikel:***

Diterima: 01-08-2024
Disetujui: 01-10-2024

***Kata Kunci:***

Environmental-Oriented Problem-Based Learning; Gender; Problem Solving; Self-Ecological Awareness

**ABSTRAK**

**Abstrak**: Peningkatan permasalahan sungai semakin kompleks memerlukan pembelajaran kontekstual yang dapat mengaitkan pembelajaran pada isu-isu lingkungan nyata dan relevan. Penelitian ini bertujuan untuk mengetahui perbedaan kemampuan pemecahan masalah dan kesadaran ekologis diri siswa melalui *Environmental-Oriented Problem-Based Learning* (EoPBL) berdasarkan indikator variabel dan jenis kelamin siswa. Jenis penelitian *quasi experimental* melibatkan siswa kelas X3 dan X5 di SMA Islam Kepanjen, Kabupaten Malang, Indonesia. Pengumpulan data menggunakan tes dan kuesioner untuk menilai kemampuan pemecahan masalah dan kesadaran ekologis diri. Hasil penelitian bahwa uji non parametrik Mann-Whitney U menunjukkan adanya perbedaan yang signifikan pada kemampuan pemecahan masalah (sig. (2-tailed) = 0.000 < 0.05) dan kesadaran ekologis diri (sig. (2-tailed) = 0.002 < 0.05) antara kelas eksperimen dan kontrol. Namun, tidak ada perbedaan yang signifikan dalam kemampuan pemecahan masalah (sig. (2-tailed) = p > 0.05) dan kesadaran ekologis diri (sig. (2-tailed) = p > 0.05) berdasarkan jenis kelamin pada kelompok eksperimen dan kelas kontrol. Implementasi model EoPBL memberikan perbedaan signifikan kemampuan pemecahan masalah dan kesadaran ekologis siswa kelas eksperimen, nilai rata-rata indikator variabel 90.16 dan 79.14 lebih tinggi dibandingkan siswa kelas kontrol 68.45 dan 70.92 yang menggunakan model pembelajaran konvensional. Perbedaan jenis kelamin siswa mempengaruhi tidak adanya perbedaan signifikan antara siswa laki-laki dan siswa perempuan.

***Abstract**: Increasingly complex river problems require contextual learning that can link learning to real and relevant environmental issues. This study aims to determine the differences in problem solving skills and ecological self-awareness of students through Environmental-Oriented Problem-Based Learning (EoPBL) based on variable indicators and student gender. The quasi-experimental study involved students from classes X-3 and X-5 at Kepanjen Islamic High School in Malang Regency, Indonesia. Data were collected using tests and questionnaires to assess problem-solving and self-ecological awareness abilities. The results showed that the Mann-Whitney U non-parametric test showed a significant difference in problem solving ability (sig. (2-tailed) = 0.000 < 0.05) and self-ecological awareness (sig. (2-tailed) = 0.002 < 0.05) between the experimental and control classes. However, there were no significant differences in problem-solving abilities (sig. (2-tailed) = p > 0.05) and self-ecological awareness (sig. (2-tailed) = p > 0.05) based on gender within the experimental and control classes. The implementation of the EoPBL model provides a significant difference in the problem solving ability and ecological awareness of experimental class students, the average value of variable indicators 90.16 and 79.14 is higher than the control class students 68.45 and 70.92 who use conventional learning models. The difference in student gender affects the absence of significant differences between male students and female students.*

## A. INTRODUCTION

The process of geographical education has evolved significantly to enhance students' skills and abilities in the 21st century. Geography learning activities are now directed towards fostering geographical thinking and problem-solving skills (Fitri et al., 2022). The efficacy of geographical skills is maximized when supported by appropriate instructional models (Islam et al., 2021). Research (Amin et al., 2020) has demonstrated that the implementation of Problem-Based Learning models, aligned with geographical skill indicators, positively impacts students' critical thinking abilities and learning outcomes in geography. Educational practices that involve problem analysis, information gathering, and solution development tend to contribute substantially to the enhancement of students' geographical competencies (Putra, Sumarmi, Deffinika, et al., 2021). Teachers must create effective learning environments (Rizal et al., 2022) that rely on students' active construction of knowledge from their experiences (Simanjuntak et al., 2021). The choice of instructional models in the classroom is a key factor in achieving educational goals (Islam et al., 2021). One instructional model that supports effective education in the 21st century is Environmental-Oriented Problem-Based Learning (EoPBL).

EoPBL is oriented towards environmental issues and is designed to enhance students' problem-solving abilities and environmental awareness. This instructional model addresses local environmental issues and problems (Fadli & Irwanto, 2020), providing learning experiences that can boost motivation and thereby improve students' problem-solving skills in geographical education (Putra et al., 2022). EoPBL encourages students to think critically and engage directly with contextual problems. In geographical education, problem-based learning models aim to find solutions for geographical issues in the surrounding environment (Buana & Putra, 2023). The strength of this instructional model lies in its emphasis on student-centered learning, which aligns with the demands of 21st-century geographical education (Mahsup et al., 2024; Silviariza et al., 2023). The learning experiences provided through this model help identify local environmental problems using a scientific approach.

Environmental issues have become one of the primary global concerns. A comprehensive study conducted by the World Economic Forum (WEF) in 2019 identified environmental problems as a global threat (Qazi & Al-Mhdawi, 2023). According to data from the Indonesian Central Statistics Agency (BPS) in 2020, river environmental problems in Indonesia are predominantly caused by pollution (Riyadi et al., 2020). Approximately 75% of domestic wastewater pollution is generated from households, public facilities, commercial areas, offices, and other sources (Osim et al., 2020). Waste is a major contributor to the increasing problem of environmental pollution (Sumarmi, Putra, Mutia, Masruroh, et al., 2024). The Ministry of Environment and Forestry (KLHK) reported that the water quality index in Indonesia in 2020 was 53.88%, an improvement from the previous year (Suriadikusumah et al., 2021). However, this improvement still fell short of the target water quality index of 55.03%.

River pollution significantly impacts human survival. Poor water quality and sanitation are linked to the degradation of river ecosystems, threatening water resources, and affecting human health by transmitting waterborne diseases such as typhoid, diarrhea, and malaria (Talema, 2023). Contaminated water accounts for 2.2% of global deaths and 6% of deaths in low-income countries (Rimba & Hirabayashi, 2023). The WHO reports that 2 billion people are at risk of contracting diarrhea due to contaminated water and food (Todd, 2020). Societies have evolved and become dependent on rivers for daily life (Cordova et al., 2022). However, the high level of water use is not matched by public awareness of river conservation, thereby affecting water quality.

In the context of geographical education, problem-solving skills and self-ecological awareness are crucial for tackling river environmental issues. Problem-solving enables students to identify, analyze, and resolve complex challenges related to river conservation (Afifah et al., 2024; Putra, Sumarmi, Fajrilia, et al., 2021) Through self-ecological awareness, students can understand the link between their actions and the impact on river sustainability (Roxas, 2023), aligning with the concept of Education for Sustainable Development (Acosta Castellanos & Queiruga-Dios, 2022). Enhancing these skills within geographical education can deepen students' understanding of environmental issues and increase their participation in river conservation efforts (Sumarmi, Putra, Mutia, Sahrina, et al., 2024). These two capabilities are interrelated, fostering a strong comprehension and integration of actions necessary for maintaining river sustainability (Rivera Maulucci, 2023), thereby contributing to the development of ecologically responsible citizens.

Crucial river problems require a multidisciplinary approach to solving. Studying environmental problems supports the integration of relevant and contextualized learning approaches by encouraging active and critical learning, thus equipping students with real environmental problem-solving skills focused on river conservation. This research also contributes to environmental learning and the achievement of Sustainable Development Goals (SDGs) in education. Through the application of the Environmental-Oriented Problem Based Learning (EoPBL) model, this research helps to improve students' problem solving skills and self-ecological awareness related to environmental issues such as river problems and conservation that are in line with the goals of the SDGs, especially in goal 4 (quality education) and goal 13 (climate action). Previous research results show that the implementation of an environmentally-focused problem-based learning model can provide an increase in students' environmental awareness and attitudes through problem solving (Amin et al., 2020; Suryawati et al., 2020). This proves the role of this model in providing student collaboration in finding solutions to environmental problems to support an attitude of self-awareness towards the environment (Salsabila et al., 2022). Therefore, this research is very important to do through environmental learning.

This research applies a problem-based learning model that focuses on the orientation of river environmental issues in the geography of problems and river conservation material. River environmental problems are presented in a local context and student investigation using the Brantasae website and other references. In addition, data analysis of the research results was reviewed based on variable indicators and student gender to determine significant differences. Meanwhile, the results of previous research conducted by Amin et al., (2020) applied a problem-based learning model on sustainable environmental development material with data analysis on critical thinking skills and environmental awareness. Suryawati et al., (2020) also used an environmental problem-based learning (EPBL) model on forest fires, gold mining, and domestic waste with data analysis only on knowledge, actions, and sensitivity to the environment to see the correlation and effectiveness of the EPBL model.

The novelty of this research compared to previous studies lies in the implementation of the EoPBL model, which emphasizes contextual learning for solving river-related issues in the surrounding area through conservation efforts while considering students' attitudes towards the environment. This approach aims to foster students' environmental awareness, making learning more meaningful. Consequently, this study aims to determine the differences in problem-solving abilities and self-ecological awareness regarding river issues and conservation using the EoPBL model, with a focus on variable indicators and student gender.

## B. RESEARCH METHOD

A pretest-posttest control group design is used in this quasi-experimental research, as shown in Table 1. The experimental class uses the Environmental-Oriented Problem-Based Learning (EoPBL) model (Suryawati et al., 2020), as outlined in Table 2, while the control class employs a direct learning model. In this study, researchers addressed three research questions:

RQ1: Based on indicators of problem-solving ability, is there a significant difference between the experimental class and the control class?

RQ2: Based on indicators of self-ecological awareness ability, is there a significant difference between the experimental class and the control class?

RQ3: Are there significant differences in problem-solving abilities and self-ecological awareness abilities based on student gender?

**Table 1.** Research Design

| Group | Pre-test | Treatment | Model | Post-test |
|---|---|---|---|---|
| Experimental N= 26 | O1 | X | Environmental-Oriented Problem Based Learning | O2 |
| Control N= 27 | O1 | - | Direct Learning | O2 |

The subjects of this research are Class X students of Kepanjen Islamic High School in Malang, Indonesia, for the 2023/2024 academic year. The students studied river problems and conservation in the even-semester geography lesson. The research sample group was selected using a purposive sampling technique by comparing the average geography learning outcomes of the students. The experimental class (X-5) consists of 26 students (9 male and 17 female), while the control class (X-3) consists of 29 students (7 male and 22 female). Figure 1 depicts the flow of research implementation.

**Tabel 2.** Activity Experimental Class

| Syntax | Learning Activity | Duration |
|---|---|---|
| River Problem Orientation | Teacher:<br>a. Provide basic concepts and local environmental issues through news videos<br>Student:<br>b. Understand in detail the issues to be discussed | Week 1 (190 mins) |
| Identify River Problems | Students can group the details of the river problems that have been discussed and the role of rivers in life. | Week 2 (190 mins) |
| Research/ Investigation of River Problems | Students conduct investigations in groups to provide solutions to solve river environmental problems that occur in the surrounding area with the media Brantasae Website and other references | |
| Presentation of Work | Students explain the results of solving problems found with presentations in class via poster media | Week 3 (190 mins) |
| Evaluation of Problem Solving Results | Teacher evaluate and conclude the appropriate environmental problem solving process | |

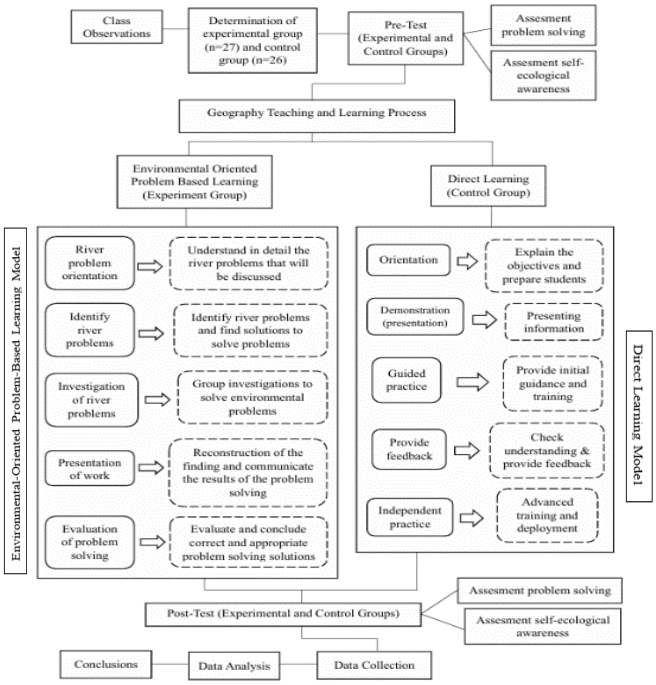


**Figure 1.** Research Flow

This research used an instrument in the form of essay questions to collect data according to indicators of problem-solving ability (Mohd Yatim et al., 2022), as in Table 3. The problem-solving ability essay questions given were ten questions each in the pre-test and post-test. The score given to each question item is adjusted to the student's level of thinking ability which is measured based on the cognitive domain level of Bloom's Taxonomy. The assessment instrument for self-ecological awareness is in the form of a questionnaire which is measured using a Likert scale with a value of 1-4. The questionnaire was adapted to indicators of self-ecological awareness (Safitri et al., 2022), as in Table 4.

**Table 3.** Indicator Problem Solving

| Indicator | Description |
|---|---|
| Identification of problems (Analyzing) | Identify and demonstrate understanding of environmental problems |
| Planning Solutions (Creating) | Create/arrange strategies for solving environmental problems |
| Resolving Problems and Implementing Solutions (Applying) | Select and apply appropriate problem solving strategies to resolve environmental problems |
| Evaluating the Problem (Evaluating) | Checking the truth and evaluating the efforts that have been made to resolve environmental problems |

Source: (Mohd Yatim et al., 2022)

**Table 4.** Indicator Self-Ecological Awareness

| Indicator | Sub-Indicator |
|---|---|
| Environmental Practices | a. Understand the meaning of environmental problems<br>b. Responsible for environmental problems in a place<br>c. Discuss environmental problems with others<br>d. Get involved in environmental awareness activities |
| Environmental Attitudes | a. Maintain environmental sustainability<br>b. Provide information regarding environmental management<br>c. Protect and improve the environment<br>d. Share solutions to environmental problems |
| Environmental Values Sustainability | a. Reduce the amount of waste by collecting recyclable materials<br>b. Do not use plastic bags to wrap items<br>c. Compost food waste into fertilizer<br>d. Throw away rubbish in the right place |

Source: (Safitri et al., 2022)

The validity of the test sheet was confirmed by Pearson product-moment correlation (r: 0.622 > r table 0.266), as was the validity of the questionnaire (r: 0.560 > r table 0.266). Reliability analysis confirmed the instrument's consistency using Cronbach Alpha values, with the test and questionnaire yielding reliability coefficients of 0.712 and 0.895, respectively. The prerequisite test results showed normal residual normality data with Kolmogorov-Smirnov (0.200 > 0.05), a linear relationship pattern in the correlation linearity test with a scatterplot, and non-homogeneous data in the variance homogeneity test (0.047 < 0.05). Due to the non-homogeneous data, non-parametric tests Mann Whitney U were used as a follow-up to the ANCOVA test analysis. The N-Gain Score test was also conducted on the pretest and posttest results in both class groups to determine the effectiveness of implementing the learning model in the classroom learning process.

## C. RESULT AND DISCUSSION

### 1. Comparative Analysis of Problem Solving

High problem-solving skills are achieved through active student participation during learning using the EoPBL model. The implementation of this model significantly enhances students' problem-solving abilities, as accurately measured by analyzing the differences in post-test results between the experimental and control classes. The average score obtained in the initial pre-test assessment of problem-solving for the experimental class was

74.71, while the control class received a lower score of 55.55. Following the intervention, the average scores of both classes increased. The experimental class achieved an average score of 90.16, surpassing the control class's score of 68.45. This discrepancy underscores the effectiveness of the EoPBL model, which utilizes contextually relevant environmental problems and a scientific resolution process (Kassymova et al., 2020). The experimental class obtained an N-Gain Score of 70.37%, demonstrating a significant improvement in students' problem-solving abilities due to the effective EoPBL model. This model facilitates active student engagement in constructing knowledge through discussions based on real-world problems (Dwikoranto et al., 2023). In contrast, the control class's average N-Gain Score of 29.02% reveals that conventional direct learning methods are less effective in improving students' problem-solving abilities.

A detailed analysis of the average scores based on problem-solving indicators, presented in Table 5, shows that the experimental class consistently outperformed the control class on all indicators, with an average score difference of 21.71. It can be concluded that students in the experimental class have higher problem-solving abilities than those in the control class. Problem-based learning in the experimental class effectively guided students in constructing knowledge to address environmental issues (Sumarmi et al., 2020). Students were able to formulate answers to problems requiring logical intelligence, courage, and active solutions in real-world situations (Amin et al., 2020).

**Table 5.** Indicators Score of Problem Solving

| Indicator Problem Solving | Experimental Class | | Control Class | |
|---|---|---|---|---|
| | Mean | Categories | Mean | Categories |
| Identification of problems | 87,82 | Very high | 69,31 | High |
| Planning Solutions | 96,15 | Very high | 83,45 | Very high |
| Resolving Problems & Implementing Solutions | 83,08 | Very high | 56,55 | Enough |
| Evaluating the Problem | 93,59 | Very high | 64,48 | High |
| **Mean Score** | **90,16** | **Very high** | **68,45** | **High** |

The experimental class's notable strength was observed in the 'creating' indicator, related to formulating viable solutions to prevent river pollution, where they achieved an exceptionally high score of 96.15. In contrast, the control class attained its highest average score of 83.45 in this same indicator, also categorized as very high. This achievement highlights that students had the opportunity to explore their thoughts and develop systematic solutions (Carrió Llach & Llerena Bastida, 2022). A significant disparity is evident in the 'applying' indicator, which involves solving problems and implementing solutions, with a score gap of 26.53 between the two classes. This disparity underscores the difficulty students in the conventional learning model face when addressing more complex questions. Meanwhile, the experimental class students demonstrated superior performance in solving complex problems due to their learning model (Hobri et al., 2020). Such performance in solving real-world problems requires students to actively form their own knowledge (Rachmawati & Rosy, 2022).

**Table 6.** Results of the Mann-Whitney U Test

| Data | Mann-Whitney U | Asymp. Sig. (2-tailed) | Significance |
|---|---|---|---|
| Problem Solving | 50.500 | 0,000 | 0,05 |
| Self-Ecological Awareness | 195.500 | 0,002 | 0,05 |

The statistical validation of the findings presented in Table 6 was analyzed using the Mann-Whitney U test, which obtained a significance value of 0.000. This value is below the 5% (0.05) significance threshold, indicating a significant difference in problem-solving abilities between the experimental class and the control class. These findings align with the research by (Fitriani et al., 2020), which asserts that environmental problem-oriented learning models are effective in enhancing students' problem-solving skills. Additionally, (Hutsalo et al., 2024) states that problem-based learning models oriented toward environmental issues prepare students to be collaborative, creative, innovative, critical, and analytical thinkers capable of effectively solving real-world environmental problems.

The significant increase in the average score of 90.16 in the experimental class, compared to the control class's average score of 68.45, credibly demonstrates the positive impact of the environmental-oriented problem-based learning model on students' problem-solving abilities. In addition to improving students' problem-solving skills, problem-based learning can also enhance collaborative skills (Lorenza et al., 2023). This model guides students in discovering facts, forming hypotheses, and drawing conclusions in problem-solving, which indirectly trains students to concentrate (Badriah et al., 2023). These findings underscore the transformative potential of environmental problem-based learning in enhancing students' problem-solving skills, providing a more meaningful understanding of river issues (Singha & Singha, 2024), and fostering students' commitment to river conservation efforts. Consequently, this approach enables students to actively engage with daily environmental challenges.

## 2. Comparative Analysis of Self-Ecological Awareness

This study evaluates the differences in students' self-ecological awareness between the experimental and control classes through post-test scores, which indicate significant progress following the treatment. The experimental class received an initial pre-test assessment with an average score of 74.71, exceeding the control class's average score of 65. After treatment with the EoPBL model, the experimental class's average score increased to 79.14, while the control class's score also increased to 70.92. Despite the post-treatment increase, the difference in average scores between the classes remained minimal. The higher average scores in the experimental class can be attributed to the environmental-oriented problem-based learning model, which engages students in active thinking to solve environmental problems, thereby instilling a sense of responsibility for environmental preservation (Rachman et al., 2020). The learning stages involved active student participation in solving environmental issues (Alkair et al., 2023).

Table 7 details the scores based on the self-ecological awareness indicator variable, showing that in the experimental class, the average score for all indicators exceeds that of the control class, with an overall average score difference of 8.22. This finding aligns with research (Anggraeni et al., 2023), which asserts that students' environmental attitudes can improve when they confront real environmental issues during a complex learning process. The students' learning activities resulted in a comprehensive understanding of complex environmental problems (Kuvac & Koc, 2019).

**Table 7.** Indicators Score of Self-Ecological Awareness

| Indicator Self-Ecological Awareness | Experimental Class | | Control Class | |
|---|---|---|---|---|
| | Mean | Categories | Mean | Categories |
| Environmental Practices | 79,81 | Good | 68,10 | Good |
| Environmental Attitudes | 79,33 | Good | 71,98 | Good |
| Environmental Values Sustainability | 78,30 | Good | 72,66 | Good |
| **Mean Score** | **79,14** | **Good** | **70,92** | **Good** |

Although the average scores in the experimental class slightly declined for each indicator, the control class showed an increase. The environmental practice indicator in the experimental class has a superior average score of 79.81, reflecting students' awareness and understanding of river environmental issues. Consistent with ecological principles, students' environmental attitudes improve when they face real environmental problems in their surroundings (Al Balushi & Ambusaidi, 2023; Putra et al., 2024). Although the control class also scored well on this indicator, their performance did not surpass the experimental class, with a significant score difference of 11.71 among other indicators. The experimental class activities, which included problem mapping, prioritizing issues, conducting investigations, group discussions, and presenting results, encouraged students to analyze various facts, events, and environmental problems (Ayerbe-López & Perales-Palacios, 2023).

The results of the Mann-Whitney U test in Table 6 further support this finding. For the ability of self-ecological awareness, there is a significant difference with a significance value of 0.002 ($p < 0.05$) between the experimental and control classes, with significance less than 0.05 (5%). The experimental class has an average score that exceeds the control class by 8.22 points. These results provide strong empirical evidence that the steps in the environmental-oriented problem-based learning model enable students to grasp and recall theories while addressing river environmental issues (Kuvac & Koc, 2019). The findings accurately depict that the integration of problem-based learning oriented towards environmental issues significantly fosters proactive self-ecological awareness behaviors in contributing to the prevention of river environmental problems (Ghani et al., 2021). The newly acquired knowledge about preventing environmental damage forms the basis for students' attitudes towards the environment (Kurokawa et al., 2023).

However, the N-Gain Score test results for the experimental class were 11.6%, indicating that the environmentally-oriented problem-based learning model was not effective in significantly increasing students' self-ecological awareness. Similarly, the control class obtained a low N-Gain Score result of 13.17%, showing that conventional direct learning was also ineffective in improving students' self-ecological awareness.

## 3. Problem Solving and Self-Ecological Awareness Based on Student Gender

The analysis of problem-solving skills and self-ecological awareness was also applied to the research subjects based on the students' gender. The students' genders were categorized as male and female. To address the research question regarding the differences in problem-solving skills and self-ecological awareness based on student gender, the Mann-Whitney U non-parametric test was utilized. This test was analyzed based on the average item scores per indicator in the experimental and control classes.

**a. Comparison of Problem-Solving Scores**

The research results indicated that male students in the experimental class had superior problem-solving abilities, with an average score of 90.88 compared to 89.75 for female students. Conversely, in the control class, the highest average score was obtained by female students at 70.51, while male students scored 61.96. In the experimental class, the difference between the average scores of male and female students was only 1.13, which was lower than the difference in the control class at 8.55.

However, the Mann-Whitney U test did not show any significant differences between male and female students in the experimental class in problem-solving abilities, with a significance value of 0.568 (p > 0.05). Similarly, in the control class, no significant differences were found based on student gender, with a significance value of 0.161 (p > 0.05). These findings align with other studies indicating no gender-based differences in problem-solving abilities, which may be attributed to the teaching methods employed by instructors without gender discrimination in the classroom (Ridhwan et al., 2020). However, other research (Deng et al., 2023) contradicts these findings by asserting that gender differences do impact problem-solving abilities.

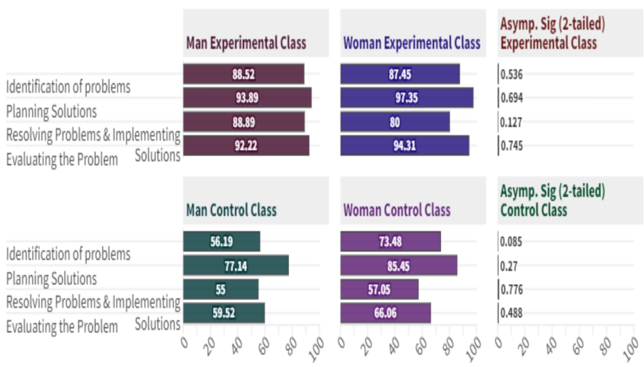


**Figure 2.** Results of Analysis of Problem-Solving Ability Variable Indicators and Mann-Whitney U Test on Gender

A detailed analysis of each indicator of problem-solving ability based on gender in the two class groups also did not show significant differences, with significance values greater than 0.05. In the experimental class, male students outperformed in indicators of problem identification (analyzing) and resolving problems & implementing solutions (applying), with a significant score difference of 8.89 in the applying indicator. This could be due to the more easily grasped learning styles of male students compared to female students (Yousaf et al., 2023). In contrast, in the control class, female students outperformed male students across all indicator items. Detailed results are presented in Figure 2.

**b. Comparison of Self-Ecological Awareness Scores**

The experimental class research results showed that female students had superior self-ecological awareness abilities with an average score of 79.92, compared to male students who scored 77.67, with a score difference of only 2.25. Similarly, in the control class, the average score of female students was 71.47, exceeding male students' average score of 69.15, with a difference of only 2.32. Females often express greater concern about climate change influenced by higher environmental awareness (Clayton et al., 2023). The results of the Mann-Whitney U test based on student gender showed no significant differences in the experimental class with a significance value of 0.317 (p > 0.05) and in the control class with a significance value of 0.412 (p > 0.05). An analysis of each indicator of self-ecological awareness also showed no significant differences based on student gender (sig. (2-tailed) = p > 0.05) (see Figure 3). However, these findings differ from the research (Rosa et al., 2023) that found gender differences in environmental concern participation.

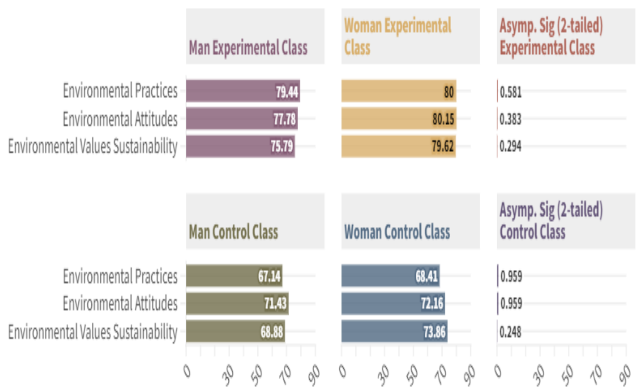


**Figure 3.** Mann-Whitney U Test Results of Gender Differences in Self-Ecological Awareness Ability

The study findings demonstrated that female students in both the experimental and control classes achieved higher average scores than male students across all indicators of self-ecological awareness. Several studies indicate that females are more concerned about the environment and possess stronger pro-environmental attitudes than males (Dean et al., 2018; Granda et al., 2024).The indicator of environmental sustainability values in both classes exhibited a higher average score difference between male and female students compared to other indicators. The difference in the experimental class is 3.83, while in the control class it is 4.98. Compared to males, females are more closely associated with nature, which may foster better environmental sustainability values through a connection to nature (Miao & Cagle, 2020). Detailed research results can be seen in Figure 3.

## D. CONCLUSIONS AND SUGGESTIONS

Based on the results of the study, the Mann-Whitney U non-parametric test resulted in a significance value of 0.000 < 0.05 on problem solving ability and a significance value of 0.002 < 0.05 on self-ecological awareness. Thus, it can be concluded that there is a significant difference in students' problem solving ability and self-ecological awareness between the experimental and control classes. The average value of the experimental class students' problem solving variable indicator is 90.16 exceeding the control class average value of 68.45 and the experimental class students' average value of self-ecological awareness is 79.14 higher than the control class 70.92. Therefore, it can be seen that students who learn using the EoPBL model have higher problem solving skills and self-ecological awareness compared to students who learn using conventional learning models. However, the results of the Mann-Whitney U non-parametric test in terms of student gender on problem solving ability resulted in a significance value of 0.568 > 0.05 in the experimental class and a significance value of 0.161 > 0.05 in the control class. Meanwhile, the self-ecological awareness resulted in a significance value of 0.317 > 0.05 in the experimental class and a significance value of 0.412 > 0.05 in the control class. These results indicate that there is no significant difference in students' problem solving ability and self-ecological awareness. Researchers recommend that the EoPBL model be implemented consistently in geography education to improve students' problem-solving abilities and self-ecological awareness. Achieving maximum results requires considering appropriate timing to foster deep environmental concern among students. Additionally, during the investigation stage, intensive guidance is necessary for students using media and the internet to ensure they remain focused.

## ACKNOWLEDGMENTS

The researcher expressed his gratitude to the Kepanjen Islamic High School, especially the students of classes X-3 and X-5 for the 2023/2024 school year, the geography teacher of the Kepanjen Islamic High School, and the supervisor of the Geography Education study program, Faculty of Social Sciences, Universitas Negeri Malang who have guided and supported the author in completing this experimental research. Greetings are also addressed to everyone involved in this challenging but satisfying research journey.

## REFERENCES

Acosta Castellanos, P. M., & Queiruga-Dios, A. (2022). From environmental education to education for sustainable development in higher education: a systematic review. *International Journal of Sustainability in Higher Education*, *23*(3). https://doi.org/10.1108/IJSHE-04-2021-0167

Afifah, N., Putra, A. K., & Haqqi, A. H. (2024). *Virtual Reality Integration in Geography: Meningkatkan Environmental Problem Solving Ability Siswa pada Kajian Konservasi DAS*. *8*(1), 11–22. https://doi.org/10.23887/jear.v8i1.67943

Al Balushi, H. M., & Ambusaidi, A. K. (2023). The influence of environmental education on Omani students self-reported environmental attitudes and behaviours. *International Research in Geographical and Environmental Education*, *32*(2). https://doi.org/10.1080/10382046.2022.2154976

Alkair, S., Ali, R., Abouhashem, A., Aledamat, R., Bhadra, J., Ahmad, Z., Sellami, A., & Al-Thani, N. J. (2023). A STEM model for engaging students in environmental sustainability programs through a problem-solving approach. *Applied Environmental Education and Communication*, *22*(1). https://doi.org/10.1080/1533015X.2023.2179556

Amin, S., Utaya, S., Bachri, S., Sumarmi, & Susilo, S. (2020). Effect of problem-based learning on critical thinking skills and environmental attitude. *Journal for the Education of Gifted Young Scientists*, *8*(2). https://doi.org/10.17478/jegys.650344

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*. https://doi.org/10.1016/j.tsc.2023.101334

Ayerbe-López, J., & Perales-Palacios, F. J. (2023). Evaluating a Secondary Education Urban Ecology Project within the Framework of a Problem-Based Learning Methodology. *Education Sciences*, *13*(9). https://doi.org/10.3390/educsci13090915

Badriah, L., Mahanal, S., Lukiati, B., & Saptasari, M. (2023). Collaborative Mind Mapping-Assisted RICOSRE to Promote Students' Problem-Solving Skills. *Participatory Educational Research*, *10*(4). https://doi.org/10.17275/per.23.65.10.4

Buana, R. T., & Putra, A. K. (2023). Peningkatan Kemampuan Berpikir Spasial: Implementasi Model Problem Based Learning melalui Pendekatan Self Efficacy Berbantuan WebGIS Inarisk. *Journal of Education Action Research*, *7*(3), 310–319. https://doi.org/10.23887/jear.v7i3.63881

Carrió Llach, M., & Llerena Bastida, M. (2022). Exploring innovative strategies in problem based learning to contribute to sustainable development: a case study.

*International Journal of Sustainability in Higher Education*, *24*(9). https://doi.org/10.1108/IJSHE-07-2021-0296

Clayton, S. D., Pihkala, P., Wray, B., & Marks, E. (2023). Psychological and Emotional Responses to Climate Change among Young People Worldwide: Differences Associated with Gender, Age, and Country. *Sustainability (Switzerland)*, *15*(4). https://doi.org/10.3390/su15043540

Cordova, M. R., Nurhati, I. S., Shiomoto, A., Hatanaka, K., Saville, R., & Riani, E. (2022). Spatiotemporal macro debris and microplastic variations linked to domestic waste and textile industry in the supercritical Citarum River, Indonesia. *Marine Pollution Bulletin*, *175*. https://doi.org/10.1016/j.marpolbul.2022.113338

Dean, J. H., Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Barber, E., Franco, L., & Fuller, R. A. (2018). Is nature relatedness associated with better mental and physical health? *International Journal of Environmental Research and Public Health*, *15*(7). https://doi.org/10.3390/ijerph15071371

Deng, X., Chen, S., Li, X., Tan, C., Li, W., Zhong, C., Mei, R., & Ye, M. (2023). Gender differences in empathy, emotional intelligence and problem-solving ability among nursing students: A cross-sectional study. *Nurse Education Today*, *120*. https://doi.org/10.1016/j.nedt.2022.105649

Dwikoranto, Dawana, I. R., & Setiani, R. (2023). Validity of Teaching Modules with Problem-Based Learning (PBL) Model Assisted by E-Book to Improve Problem-Solving Skills on Renewable Energy Material and Implementation of Independent Learning Curriculum. *Journal of Physics: Conference Series*, *2623*(1). https://doi.org/10.1088/1742-6596/2623/1/012015

Fadli, A., & Irwanto. (2020). The effect of local wisdom-based ELSII learning model on the problem solving and communication skills of pre-service islamic teachers. *International Journal of Instruction*, *13*(1). https://doi.org/10.29333/iji.2020.13147a

Fitri, L. S., Rosyida, F., Putra, A. K., Wirahayu, Y. A., & Selviana, N. (2022). The Effect of Geographical Inquiry Learning Using SETS Approach to Complex Problem-Solving Abilities on Environmental Conservation Material. *Pegem Egitim ve Ogretim Dergisi*, *12*(4). https://doi.org/10.47750/pegegog.12.04.07

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). The effects of integrated problem-based learning, predict, observe, explain on problem-solving skills and self-efficacy. *Eurasian Journal of Educational Research*, *2020*(85). https://doi.org/10.14689/ejer.2020.85.3

Ghani, A. S. A., Rahim, A. F. A., Yusoff, M. S. B., & Hadie, S. N. H. (2021). Effective Learning Behavior in Problem-Based Learning: a Scoping Review. In *Medical Science Educator* (Vol. 31, Issue 3). https://doi.org/10.1007/s40670-021-01292-0

Granda, L., Moya-Fernández, P. J., Soriano-Miras, R. M., & González-Gómez, F. (2024). Pro-environmental behaviour in household water use. A gender perspective. *Sustainable Water Resources Management*, *10*(2). https://doi.org/10.1007/s40899-023-01027-6

Hobri, Ummah, I. K., Yuliati, N., & Dafik. (2020). The effect of jumping task based on creative problem solving on students' problem solving ability. *International Journal of Instruction*, *13*(1). https://doi.org/10.29333/iji.2020.13126a

Hutsalo, L., Skliar, I., Abrosimov, A., Kharchenko, N., & Ordanovska, O. (2024). Strategies for developing critical thinking and problem-based learning in the modern educational environment. *Multidisciplinary Science Journal*, *6*. https://doi.org/10.31893/multiscience.2024ss0209

Islam, M. N., Sumarmi, S., Putra, A. K., Sugiyati, P., & Salsabilah, S. (2021). The Effect of Interactive Blended-Problem Based Learning Assisted Virtual Classroom on Critical Thinking Skills of Students of The Society Era 5.0. *Jurnal Geografi Gea*, *21*(2). https://doi.org/10.17509/gea.v21i2.38862

Kassymova, G., Akhmetova, A., Baibekova, M., Kalniyazova, A., Mazhinov, B., & Mussina, S. (2020). E-learning environments and problem-based learning. *International Journal of Advanced Science and Technology*, *29*(7 Special Issue).

Kurokawa, H., Igei, K., Kitsuki, A., Kurita, K., Managi, S., Nakamuro, M., & Sakano, A. (2023). Improvement impact of nudges incorporated in environmental education on students' environmental knowledge, attitudes, and behaviors. *Journal of Environmental Management*, *325*. https://doi.org/10.1016/j.jenvman.2022.116612

Kuvac, M., & Koc, I. (2019). The effect of problem-based learning on the environmental attitudes of preservice science teachers. *Educational Studies*, *45*(1). https://doi.org/10.1080/03055698.2018.1443795

Lorenza, M., Setyawan, D., & Miftahussa'adiah. (2023). Impelementasi Model Pembelajaran Berbasis Masalah terhadap Keterampilan Kolaborasi Siswa SMK. *Paedagoria: Jurna; Kajian, Penelitian Dan Pengembangan Kependidikan*, *14*(3), 352–355. https://doi.org/10.31764/paedagoria.v14i3.16219

Mahsup, Muhardini, S., Sahara, A., & Solehah, A. (2024). Development Of Problem Based Investigation Model Learning Tools Based On Local Wisdom To Improve Students' Critical Thinking Skills. *Paedagoria : Jurnal Kajian, Penelitian Dan Pengembangan Kependidikan*, *15*(3), 390–396. https://doi.org/10.37251/isej.v5i2.985

Miao, R. E., & Cagle, N. L. (2020). The role of gender, race, and ethnicity in environmental identity development in undergraduate student narratives. *Environmental Education Research*, *26*(2). https://doi.org/10.1080/13504622.2020.1717449

Mohd Yatim, S. S. K., Saleh, S., Zulnaidi, H., & Yatim, S. A. M. (2022). Effects of integrating a brain-based teaching approach with GeoGebra on problem-solving abilities. *International Journal of Evaluation and Research in Education*, *11*(4). https://doi.org/10.11591/ijere.v11i4.22873

Osim, E. E., Goddymkpa, C. P., & Umoffong, N. J. (2020). Community preparation for domestic wastewater management development in Jakarta. *Int J Innov Sci Res Technol*, *5*(7).

Putra, A. K., Khalidy, D. Al, & Irawan, L. Y. (2024). Student Perceptions of Environmental Sustainability : Insights into Green Campus Innovations and Geospatial Analysis at Universitas Negeri Malang. *Visions For Sustainability*, *22*(June), 1–39. https://doi.org/10.13135/2384-8677/10250

Putra, A. K., Purwanto, Islam, M. N., Hidayat, W. N., & Fahmi, M. R. (2022). Development Of Mobile Virtual Field Trips In Ijen Crater Geosites Based On 3600 Auto Stereoscopic And Geospatial Technology As Geography Learning Media. *Geojournal of Tourism and Geosites* , *41*(2). https://doi.org/10.30892/GTG.41216-850

Putra, A. K., Sumarmi, A. S., Fajrilia, A., Islam, M. N., & Yembuu, B. (2021). Effect of Mobile-Augmented Reality (MAR) in Digital Encyclopedia on The Complex Problem Solving and Attitudes of Undergraduate Student. *International Journal of Emerging Technologies in Learning*, *16*(7). https://doi.org/10.3991/ijet.v16i07.21223

Putra, A. K., Sumarmi, Deffinika, I., & Islam, M. N. (2021). The effect of blended project-based learning with stem approach to spatial thinking ability and geographic skill. *International Journal of Instruction*, *14*(3). https://doi.org/10.29333/iji.2021.14340a

Qazi, A., & Al-Mhdawi, M. K. S. (2023). Exploring dependencies among global environmental, socioeconomic, and technological risks. *Environmental Impact Assessment Review*, *98*. https://doi.org/10.1016/j.eiar.2022.106912

Rachman, I., Sugimaru, C., & Matsumoto, T. (2020). Use of Problem Based Learning (PBL) Model To Improve Learning Outcomes in Environmental Education. *Journal of Environmental Science and Sustainable Development*, *3*(1), 114–141. https://doi.org/10.7454/jessd.v3i1.1039

Rachmawati, V. P., & Rosy, B. (2022). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar Siswa Di Masa Pandemi Covid-19. *Paedagoria : Jurnal Kajian, Penelitian Dan Pengembangan Kependidikan*, *13*(2), 187. https://doi.org/10.31764/paedagoria.v13i2.10530

Ridhwan, Sumarmi, Ruja, I. N., Utomo, D. H., & Sari, R. M. (2020). Measuring students environmental problem solving ability across gender and school differences using paper based testing. *International Journal of Emerging Technologies in Learning*, *15*(13). https://doi.org/10.3991/ijet.v15i13.11709

Rimba, A. B., & Hirabayashi, Y. (2023). Interlinkages of Water-Related SDG Indicators Globally and in Low-Income Countries. *Water (Switzerland)*, *15*(4). https://doi.org/10.3390/w15040613

Rivera Maulucci, M. S. (2023). *Pathways to Sustainability: Examples from Science Teacher Education*. https://doi.org/10.1007/978-3-031-13536-1_6

Riyadi, B. S., Alhamda, S., Airlambang, S., Anggreiny, R., Anggara, A. T., & Sudaryat. (2020). Environmental damage due to hazardous and toxic pollution: A case study of citarum river, west java, Indonesia. *International Journal of Criminology and Sociology*, *9*. https://doi.org/10.6000/1929-4409.2020.09.211

Rizal, S., Putra, A. K., Suharto, Y., & Wirahayu, Y. A. (2022). Creative Thinking And Process Science Skill: Self-Organized Learning Environment On Watershed Conservation Material. *Jurnal Pendidikan IPA Indonesia*, *11*(4). https://doi.org/10.15294/jpii.v11i4.39571

Rosa, C. D., Larson, L. R., Collado, S., Cloutier, S., & Profice, C. C. (2023). Gender Differences in Connection to Nature, Outdoor Preferences, and Nature-Based Recreation Among College Students in Brazil and the United States. *Leisure Sciences*, *45*(2). https://doi.org/10.1080/01490400.2020.1800538

Roxas, G. K. T. (2023). "Self-care is being attentive to yourself": using assemblages to examine discursive-material practices of self-care among Filipino university students. *International Journal of Qualitative Studies on Health and Well-Being*, *18*(1). https://doi.org/10.1080/17482631.2023.2247619

Safitri, D., Fahrurrozi, Nurhasanah, N., Marini, A., Subandi, O. U., Tadjuddin, S., Wirasti, M. K., & Kasirah, I. (2022). The Effect of Eco-label and Renewable Energy Projects Knowledge on Environmental Awareness for Elementary School Students. *International Journal of Energy Economics and Policy*, *12*(3). https://doi.org/10.32479/ijeep.13037

Salsabila, T. I., Putra, A. K., & Matos, T. (2022). Mobile Virtual Field Trip and Geography Education: Potential Exploration of Complex Problem Solving and Spatial Intelligence Capabilities. *International Journal of Interactive Mobile Technologies*, *16*(24). https://doi.org/10.3991/ijim.v16i24.36157

Silviariza, W. Y., Sumarmi, Utaya, S., Bachri, S., & Handoyo, B. (2023). Development of Evaluation Instruments to Measure the Quality of Spatial Problem Based Learning (SPBL): CIPP Framework. In *International Journal of Instruction* (Vol. 16, Issue 2). https://doi.org/10.29333/iji.2023.16223a

Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, D. (2021). Effectiveness of problem-based learning combined with computer simulation on students' problem-solving and creative thinking skills. *International Journal of Instruction*, *14*(3). https://doi.org/10.29333/iji.2021.14330a

Singha, R., & Singha, S. (2024). *Application of Experiential, Inquiry-Based, Problem-Based, and Project-Based Learning in Sustainable Education*. https://doi.org/10.4018/978-1-6684-9859-0.ch006

Sumarmi, Bachri, S., Baidowi, A., & Aliman, M. (2020). Problem-based service learning's effect on environmental concern and ability to write scientific papers. *International Journal of Instruction*, *13*(4). https://doi.org/10.29333/iji.2020.13411a

Sumarmi, Putra, A. K., Mutia, T., Masruroh, H., Rizal, S., Khairunisa, T., Arinta, D., Arif, M., & Ismail, A. S. (2024). Local Wisdom for Global Challenges: Memayu Hayuning Bawono as a Model for Sustainable Environmental Practices. *International Journal of Sustainable Development and Planning*, *19*(2). https://doi.org/10.18280/ijsdp.190210

Sumarmi, Putra, A. K., Mutia, T., Sahrina, A., & Osman, S. (2024). A technocreativity learning model based on environmental volunteers for waste management. *Visions For Sustainability*, *21*, 67–95. https://doi.org/10.13135/2384-8677/9499

Suriadikusumah, A., Mulyani, O., Sudirja, R., Sofyan, E. T., Maulana, M. H. R., & Mulyono, A. (2021). Analysis of the water quality at Cipeusing river, Indonesia using the pollution index method. *Acta Ecologica Sinica*, *41*(3). https://doi.org/10.1016/J.CHNAES.2020.08.001

Suryawati, E., Suzanti, F., Zulfarina, Putriana, A. R., & Febrianti, L. (2020). The implementation of local environmental problem-based learning student worksheets to strengthen environmental literacy. *Jurnal Pendidikan IPA Indonesia*, *9*(2). https://doi.org/10.15294/jpii.v9i2.22892

Talema, A. (2023). Causes, negative effects, and preventive methods of water pollution in Ethiopia. In *Quality Assurance and Safety of Crops and Foods* (Vol. 15, Issue 2). https://doi.org/10.15586/qas.v15i2.1271

Todd, E. (2020). Food-borne disease prevention and risk assessment. In *International Journal of Environmental Research and Public Health* (Vol. 17, Issue 14). https://doi.org/10.3390/ijerph17145129

Yousaf, Y., Shoaib, M., Hassan, M. A., & Habiba, U. (2023). An intelligent content provider based on students learning style to increase their engagement level and performance. *Interactive Learning Environments*, *31*(5). https://doi.org/10.1080/10494820.2021.1900875