DEVELOPING IOT-BASED LEARNING STRATEGIES FOR ENHANCING HIGHER-ORDER THINKING SKILLS IN ENVIRONMENTAL ISSUES

Flaurencia Irene Mulya IRAWATI [1], Dwi SULISWORO [2]

[1] Universitas Ahmad Dahlan, Faculty of Education and Teacher Training,

https://orcid.org/0009-0005-1759-4751

[2] Universitas Ahmad Dahlan, Faculty of Education and Teacher Training,

https://orcid.org/0000-0002-7625-8505

ABSTRACT

Raising awareness about global issues presents a complex challenge, as providing learners real-world experiences of natural phenomena is complex. Traditional learning approaches primarily rely on text, images, and videos, often needing more to deliver authentic experiences. Therefore, there is a need to develop learning strategies that leverage real-time data, such as smart water quality sensors based on the Internet of Things (IoT), capable of measuring conductivity, pH, oxygen levels, salinity, and turbidity in various environments like ponds, rivers, and lakes. These sensors can be further developed to facilitate automated fish and shrimp farming monitoring. However, the issue lies in the need for hands-on learning opportunities that utilize cutting-edge technology, particularly in environmental problems. Hence, this research aims to design a suitable IoT-based learning framework to enhance higher-order thinking skills in addressing environmental issues, specifically water pollution. The development of this IoT-based application will support educational efforts, particularly in natural environments. This strategy aims to foster higher-order thinking skills in elementary school students, encouraging activities such as identification, comparison, and classification of various concepts and phenomena. The implementation and testing of problem-based learning supported by this application will be carried out at the junior high school level.

Keywords: Environmental awareness, Learning strategies, Internet of Things (IoT), Smart water quality sensor, Hands-on learning, Higher order thinking skills

1. INTRODUCTION

Natural Sciences is a subject that delves into the study of life's phenomena, aiming to produce high-quality human resources through science education [1]. Traditional learning methods, where teachers dominate the process by presenting information to passive students, often result in abstract understanding and reduced motivation. Student-centred learning models, such as the Problem-Based Learning (PBL) model, have been introduced, which actively involves students in learning activities and encourages critical thinking and problem-solving skills.

This research explores the impact of student-centred learning models, particularly the PBL model, on students' motivation. The PBL model presents real-life problems that engage students in collaborative learning, fostering independence and confidence. Pollution and environmental damage are relevant topics in the science curriculum, particularly in junior high schools, as they directly relate to students' lives [2].

Unfortunately, science learning at the junior high school level often lacks adequate instructional media, resulting in less detailed explanations that hinder concept understanding. To enhance

the learning experience and provide direct access to phenomena, Internet of Things (IoT)-based devices have emerged as valuable tools [3]-[5]. One such device is the IoT Smart water quality sensor, which allows students to measure various water parameters, such as pH, conductivity, oxygen levels, salinity, and turbidity [6].

This research seeks to explore the integration of the IoT Smart water quality sensor with the PBL model, aiming to enhance students' understanding of pollution and environmental issues while boosting their learning motivation. By presenting real-world problems and utilizing innovative technology, this study aims to determine student responses to combining the IoT Smart water quality sensor and problem-based learning.

This research endeavours to shed light on the effectiveness of this combined approach and its potential implications for science education. Understanding the impact of student-centred learning models and technological integration on student motivation is vital for creating dynamic and engaging learning environments that foster knowledge acquisition and skill development.

2. METHODS

This research adopts a descriptive research design to investigate the impact of the IoT-assisted PBL model using smart water quality sensors on water pollution material. The survey method collects extensive data on student responses to the implemented learning approach.

Participants in this study consist of 28 7th-grade students from a particular junior high school in Yogyakarta, Indonesia. The data collection technique involves using questionnaires comprising 20 questions categorized into four aspects: usefulness, ease of use, ease of learning, and satisfaction. The questionnaire utilizes the Likert scale, where students were asked to select their answers from four options: strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD).

The analysis technique employed in this research is descriptive, utilizing percentages and average scores. Descriptive statistics were used to organize and analyze data to clearly and concisely understand the results. The research instrument used is the questionnaire, designed to measure students' responses to the PBL model assisted by IoT-based smart water quality sensors. The research is carried out in several stages of learning activities, as shown in Table 1.

Table 1. Learning Activities Problem-Based Learning Assisted by IoT

PBL Syntax	Teacher Activities
Student orientation to the problem	Introduce and explain the problem
Organize students	Helping students to organize and define problem-solving presented and distribute LKPD
Individual and group research guide	Assist students in gathering information appropriate to the problems presented by making observations and explaining how to use the IoT smart water quality sensor.
Develop and present the work.	Help students to prepare appropriate work and become a moderator in presentations.
Analyze and evaluate the problem-solving process	Evaluate and reflect

The combination of survey-based data collection, descriptive analysis, and the implementation of the IoT-assisted PBL model aims to uncover valuable insights into students' responses to this

innovative learning approach and its impact on their motivation and understanding of pollution and environmental issues.

3. RESULT AND DISCUSSION

The study involved 28 students in a single class, where the PBL model was implemented with the assistance of the IoT smart water quality sensor. The research aimed to assess students' responses to the learning approach through a questionnaire comprising 20 questions, categorized into usefulness, ease of use, ease of learning, and satisfaction. Figure 1 presents the percentage of student responses for each category.

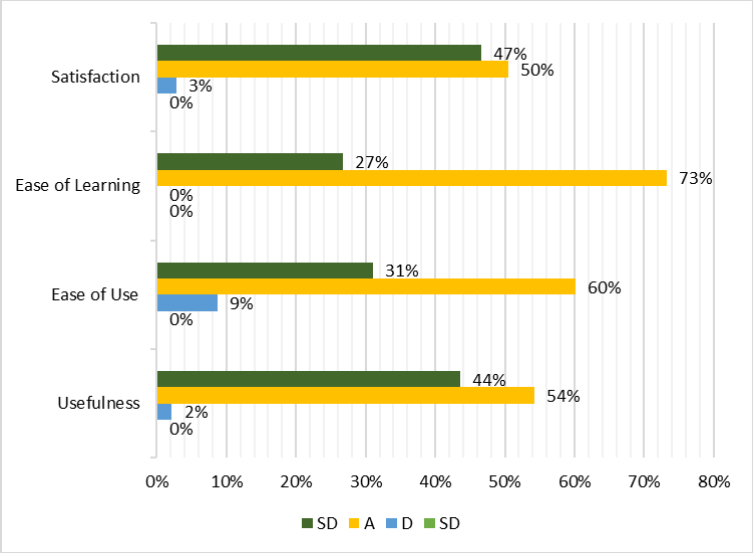

Figure 1. Score Percentage Chart for Each Category

The diagram shows that students mostly agreed and strongly agreed with all categories, with no students scoring one or strongly disagreed. However, some students did express disagreement or a score of 2. The average score for each category and overall is shown in Table 2.

Table 2. Average Total Score and Each Category

Category	$\bar{X}$	Category
Usefulness	3.41	Very good
Ease of use	3.21	
Ease of learning	3.27	
Satisfaction	3.47	
Average	3.34	

The data from the average score calculations indicate that the overall average is 3.34. All average scores obtained for each category are above three, showing very good student responses. The category with the highest average score is satisfaction, at 3.47. It suggests that students are content with the learning approach, finding it enjoyable and motivating. The PBL learning model, assisted by the IoT smart water quality sensor, allows students to explore information independently and actively engage in solving contextual problems. According to previous research, the PBL model triggers curiosity, investigation, and critical thinking, enhancing student interest and understanding of concepts [7]-[9].

Students find the learning process more accessible with the PBL model, as they are actively involved in problem-solving [10]. Applying the PBL model to environmental pollution material positively affects students, creating an enjoyable learning atmosphere through discussions to solve presented problems [11]. Moreover, using IoT smart water quality sensors contributes to students' ease of learning, as they can easily understand the features and functioning of the IoT website. The IoT sensor enables students to measure various water parameters accurately, identifying and solving water pollution problems. The data provided by the IoT sensor helps students understand concepts more clearly, preventing abstract understanding and enhancing motivation.

In conclusion, implementing the PBL learning model assisted by the IoT smart water quality sensor yielded highly positive student responses. The approach fostered a better understanding of pollution and environmental issues and increased motivation and engagement in learning. IoT technology in science learning has proven effective in providing a more flexible and concrete representation of abstract concepts, further enhancing student achievement and interest [12]-[15].

Overall, the findings of this research suggest that integrating the PBL model with IoT-based smart water quality sensors can significantly improve science education by fostering active learning, problem-solving skills, and overall student satisfaction, as another finding suggestion [16,[17]. These positive results encourage further exploration of student-centred learning models and the integration of innovative technologies to optimize learning outcomes in science education.

4. CONCLUSION

The PBL model and IoT smart water quality sensors provided students with opportunities for independent exploration and problem-solving, leading to enhanced understanding and interest in the subject matter. The IoT sensors allowed students to measure various water parameters accurately and remotely, facilitating a more profound comprehension of water pollution issues and encouraging active participation in learning. Integrating the PBL model with IoT technology proved to be a practical approach in science education. It improved students' understanding of pollution and environmental issues and fostered greater motivation and engagement during learning. This research emphasizes the importance of student-centred learning models and integrating innovative technologies to create dynamic and effective learning environments. The findings of this research support the notion that student-centred learning models, such as the PBL model, combined with IoT technology, can significantly improve science education and contribute to the development of well-rounded, motivated, and capable individuals prepared to address real-world challenges in environmental sustainability. As educators continue to refine their teaching methodologies, incorporating such innovative approaches can pave the way for a more effective and engaging learning experience for students, empowering them to become active participants in shaping a sustainable future.

5. ACKNOWLEDGMENT

This research was funded by the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia under contract number: 181/E5/PG.02.00.PL/2023 (19 June 2023), 0423.11/LL5-INT/AL.04/2023 (22 June 2023, 040/PPS-PTM/LPPM UAD/VI/2023 (24 June 2023).

REFERENCES

[1] Kasmuri, A., Dwi Astuti, I., & Amalia, A. (2020). Green economy in Indonesia: Challenges and opportunities in the pandemic era. IOP Conference Series: Earth and Environmental Science, 423(1), 012060.

[2] Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: a systematic review of the research. Environmental Education Research, 25(6), 791-812.

[3] Erdiana, I. W., Prasetyo, M. F., & Winarno, A. (2020). Integration of Internet of Things (IoT) technology in green learning for junior high school students. Journal of Physics: Conference Series, 1546(1), 012056.

[4] Daud, N. M., Yusoff, M. Z., & Hamid, N. R. A. (2021). Developing IoT-based environment education module for primary schools in Malaysia. Journal of Physics: Conference Series, 1747(1), 012064.

[5] Fitrianawati, M., & Sulisworo, D. (2019). An Integrated Internet of Things (IoT) on the Problem-Based Learning Strategy for Climate Issue: A Preliminary Design An Integrated Internet of Things (IoT) on the Problem-Based Learning Strategy for Climate Issue: A Preliminary Design. In The 5th International Conference On Educational Research And Practice (Icerp). Educating The Digital Society: Integrating Humanistic and Scientific Values, November (pp. 242-248).

[6] Sulisworo, D., Suwondo, N., Erviana, V. Y., & Fitrianawati, M. (2019). The collaborative environment using the Internet of Things in thematic-based learning at the primary school in Indonesia. Інформаційні технології і засоби навчання, (72,№ 4), 55-66.

[7] Müller, F. H., & Louw, J. (2004). Learning environment, motivation and interest: Perspectives on self-determination theory. South African journal of psychology, 34(2), 169-190.

[8] Müller, F. H., & Louw, J. (2004). Learning environment, motivation and interest: Perspectives on self-determination theory. South African journal of psychology, 34(2), 169-190

[9] Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). PBLPOE: A Learning Model to Enhance Students' Critical Thinking Skills and Scientific Attitudes. *International Journal of Instruction*, *13*(2), 89-106.

[10] Maudsley, G., & Stevens, J. (2000). Promoting professional knowledge, experiential learning and critical thinking for medical students. *Medical education*, *34*(7), 535-544.

[11] Pratiwi, I., Sutresna, Y., & Helina, N. (2023). Application of the Problem-Based Learning (PBL) Model on Environmental Pollution Materials to Increase Motivation and Learning Outcomes. *Journal Of Biology Education Research (JBER)*, *4*(1), 31-41.

[12] Gul, S., Asif, M., Ahmad, S., Yasir, M., Majid, M., Malik, M. S. A., & Arshad, S. (2017). A survey on the role of the Internet of Things in education. International Journal of Computer Science and Network Security, 17(5), 159-165.

[13] Scaradozzi, D., Cesaretti, L., Screpanti, L., Costa, D., Zingaretti, S., & Valzano, M. (2019). Innovative tools for teaching marine robotics, IoT and control strategies since the primary school. In Smart learning with educational robotics (pp. 199-227). Springer, Cham.

[14] Sulisworo, D., Fitrianawati, M., Subrata, A. C., Kalid, K. S., Ahmad, W. F. W., & Amar, M. S. S. (2022). Designing IoT-based Smart Weather System to Promote Critical Thinking Skills. TEM Journal, 11(2), 791.

[15] Nour, A., & Obeidallah, T. (2021). Internet of Things (IoT) in Education: A Review of the Literature. Education Sciences, 11(4), 167. doi:10.3390/educsci11040167

[16] Kalid, K. S., Ahmad, W. F. W., Amar, M. S. S., Sulisworo, D., Fitrianawati, M., & Subrata, A. C. (2022, May). A Proposed Implementation of Internet of Things as a

Teaching Aid for Learning Science Collaboratively. In 2022 Applied Informatics International Conference (AiIC) (pp. 131-136). IEEE.

[17] Kalid, K. S., Ahmad, W. F. W., Amar, M. S. S., Sulisworo, D., Fitrianawati, M., & Subrata, A. C. (2022). An Internet of Things-Based E-Learning Implementation to Support Collaborative Learning in Science Subject. Platform: A Journal of Science and Technology, 5(1), 43-53.