THE EFFECT OF PROBLEM-BASED LEARNING MODEL ON MATHEMATICAL CREATIVE THINKING ABILITY OF HEALTH VOCATIONAL HIGH SCHOOL STUDENTS

Hafiza Widia Sari[1*)], Aulia Stephani[2]
[1,2]*Universitas Islam Riau, Indonesia*
[1*)]hafiza.widiasari@gmail.com

Received: 05-07-2024; **Accepted**: 13-09-2024 ; **Published**: 30-10-2024

Abstract. This study aims to determine the effect of Problem Based Learning model on mathematical creative thinking ability of Bengkalis Health Vocational School students. This type of research is quasi-experimental research with a research design of Nonequivalent Control Group Design. The population of this study were all grade X students of SMK Kesehatan in the 2023/2024 school year. The samples of this study were students of class X Pharmacy A as the control class and class X Pharmacy B as the experimental class, with a total of 19 students each in the control class and 20 students in the experimental class. Data collection instruments used Pretest and Posttest sheets, which were analyzed descriptively and inferentially. Based on the Mann-Whitney U test for data that is not normally distributed, the Asymp.Sig (2-tailed) value = 0.001 (0.001 < 0.05) is obtained which indicates that H_0 is rejected and H_1 is accepted, so there is a significant difference between the average mathematical creative thinking ability of experimental and control class students. Judging from the posttest score, it is known that the creative thinking ability of students using the Problem-Based Learning model is higher than the conventional model, with an average increase in creative thinking ability of 38.1 in the experimental class and 33.89 in the control class. Thus, it can be concluded that there is an effect of the Problem-Based Learning model on students' creative thinking skills.
Keywords: *Problem Based Learning, Mathematical Creative Thinking, Conventional Learning*

1. INTRODUCTION

Education has an important role in developing students' critical and creative thinking skills [1], [2]. The existence of quality education can shape the character and competencies needed to face challenges in the modern world [3], [4]. Education makes students more capable of exploring new ideas and thinking analytically in solving problems [5]–[7]. It also encourages collaboration and communication between students, which is essential for creating a conducive learning environment. With the right approach, education can inspire students to continue learning and developing [8]–[10]. Therefore, one of the keys to a school's success in achieving educational goals is to implement innovative and student needs-based teaching methods.

School is an important place for students' character development and academic ability [10]–[13]. Conducive learning in schools helps students feel comfortable and motivated to learn optimally [12], [14], [15]. Schools also provide an environment that supports collaboration, where students can learn together and exchange ideas [16], [17]. With the guidance of teachers, students learn to solve problems and think critically in facing

ISSN: 2620-4129
E-ISSN: 2621-3885

various challenges [18]–[20]. In addition, schools play a role in shaping attitudes of discipline and responsibility through learning activities and applied rules [21]–[23]. Therefore, one of the determining factors for success in the teaching and learning process is creating a classroom atmosphere that supports active student engagement.

The classroom is the primary environment for students to acquire knowledge and develop various skills [24]–[27]. Effective classrooms encourage collaboration between students, allowing them to share ideas and learn interactively [28], [29]. In a supportive classroom, students are more motivated to explore new ideas and think critically [30]. Teachers play an important role in creating a supportive atmosphere, with teaching methods that are engaging and relevant to student development [31], [32]. Thus, the classroom is not only a place to learn, but also a place to grow socially and emotionally [33]–[35]. One of the keys to success in achieving this goal is active and participatory learning.

Learning is an important process in shaping students' thinking and skills [36], [37]. It serves as a foundation for students to understand concepts and apply them in everyday life. Through effective learning, students are invited to actively engage and participate in the learning process, thus improving their understanding and creativity [38], [39]. The right approach to learning can create an environment that supports the exploration of ideas and collaboration between students [40]. With appropriate methods, students not only gain knowledge, but also the ability to solve problems independently [35]. Thus, one of the effective approaches in learning is Problem-based Learning which encourages students to think critically and creatively.

Problem Based Learning is a learning method that focuses on developing students' ability to solve problems through active and structured learning experiences [41], [42]. Problem Based Learning engages students to think critically and creatively in dealing with real problems that are relevant to everyday life [43], [44]. Learning with this method allows students to collaborate, discuss and exchange ideas in groups, thus improving communication and cooperation skills [45], [46]. In addition, this method encourages students to be independent in seeking information and developing innovative solutions. Through this approach, students become more involved in the learning process and are motivated to explore deeper knowledge. Problem-Based Learning not only improves concept understanding but also equips students with important skills that can be applied outside the classroom [47].

Findings in the field show that students who are accustomed to conventional learning methods often have difficulty adapting to problem-based learning models. This obstacle results in low participation and lack of development of student creativity in the learning process. Based on these problems, the author is interested in examining further and conducting research with the title "The Effect of Problem-Based Learning Model on Mathematical Creative Thinking Ability of Health Vocational High School Students".

2. RESEARCH METHOD

This research employs a quasi-experimental design utilizing a nonequivalent control group framework. The study focuses on the population of class X students at SMK Kesehatan during the 2023/2024 academic year. The sample comprises two classes: class X Pharmacy A, designated as the control group with 19 students, and class X Pharmacy B, serving as the experimental group with 20 students.

The research investigates two primary variables: the independent variable and the dependent variable. The independent variables are represented by the Problem Based Learning model implemented in the experimental class, while the Conventional model is applied in the control class. The dependent variable under examination is the mathematical creative thinking ability of students at SMK Kesehatan Bengkalis.

Data collection was conducted using Pretest and Posttest assessments in the form of descriptive questions. The researchers utilized test techniques to gather information regarding students' mathematical creative thinking skills. For data analysis, two techniques were employed: descriptive analysis and inferential analysis, which included a normality test followed by the Mann-Whitney U test (U-Test) to evaluate the results.

3. RESULTS AND DISCUSSION

3.1 Results

The research was conducted in class XA Pharmacy and XB Pharmacy of SMK Kesehatan. Class XA Pharmacy as a control class that uses conventional learning while XB Pharmacy as an experimental class by giving treatment using the *Problem Based Learning* model. Before the two classes were given different treatments between the control class and the experimental class, the initial score *(Pretest) was* taken. Data from the *Pretest* knowledge score *was* used to see whether there was a difference in students' mathematical creative thinking ability between the control class and the experimental class.

Descriptive Analysis

From the results of the *Pretest* and *Posttest* that have been carried out in both classes, it can be analyzed descriptively as follows:

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Pretest Eksperimen	20	19	44	639	31,95	8,376
Posttest Eksperimen	20	25	94	1401	70,05	19,163
Pretest Kontrol	19	19	38	558	29,37	6,693
Posttest Kontrol	19	25	94	1202	63,26	18,095
Valid N (listwise)	19					

Figure 1. Data on Pretest and Posttest Results of Experimental Classes and Control Classes

Above, it is known that the number of experimental class students is 20 students and the control class is 19 students. on the Pretest of the experimental class there is a minimum

ISSN: 2620-4129
E-ISSN: 2621-3885

value of 19 and a maximum value of 44. On the Posttest of the experimental class there was a minimum value of 25 and a maximum value of 94. While in the Pretest of the control class there is a minimum value of 19 and a maximum value of 38. In the Posttest of the control class there is a minimum value of 25 and a maximum value of 94. The average of the experimental Pretest was 31.95, and the experimental Posttest was 70.05. Meanwhile, the average of the control Pretest is 29.37, and the control Posttest is 63.26. The standard deviation value of the experimental Pretest is 8.376 and the experimental Posttest is 19.163. While the standard deviation value of the control Pretest is 6.693 and the control Posttest is 18.095. Descriptive statistics can be understood that the value of the Posttest results of the experimental class is higher than the control class. Therefore, it is concluded that the value of the creative thinking ability of the experimental class is better than the control class descriptively.

Inferential Analysis

Pretest and *Posttest* scores of students were analyzed statistically using the data normality test, because the data was not normally distributed, a non-parametric test was carried out, namely the Man Whitney U test.

Pretest Data Normality Test

Pretest results that have been carried out in both classes can be seen in the appendix which is summarized as follows:

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Kemampuan Berfikir Kreatif	Pretest Eksperimen	,177	20	,102	,914	20	,076
	Pretest Kontrol	,175	19	,127	,880	19	,021

a. Lilliefors Significance Correction

Figure 2. Normality Test Results of Pretest Data for Experimental and Control Classes

On the basis of decision-making:

- If the significance value (sig.) $> \alpha$ with $\alpha = 0{,}05$, then the data is normally distributed**.**
- If the significance value (sig.) $< \alpha$ with $\alpha = 0{,}05$, then the data is not normally distributed.

Based on the table above, it can be obtained the *Shapiro-Wilk* significance value for the experimental class *Pretest* data > 0,05 which is (0.076). While the *Shapiro-Wilk* significance value for the control class *Pretest* data is (0.021). < 0,05 which is (0.021). So it can be concluded that the data is not normally distributed, because one of them is not normally distributed, namely the control class, so overall the data is not normally distributed.

Mann Whitney U Test (U-Test) ***Pretest***

The Mann-Whitney U test (U-Test) of the pretest data that has been carried out in both classes can be seen in the follow*:*

Test Statistics[a]

	Kemampuan Berfikir Kreatif
Mann-Whitney U	158,500
Wilcoxon W	348,500
Z	-,906
Asymp. Sig. (2-tailed)	,365
Exact Sig. [2*(1-tailed Sig.)]	,380[b]

a. Grouping Variable: Kelas

b. Not corrected for ties.

Figure 3. Mann-Whitney U Test Results of Experimental Class and Control Class Pretest

On the basis of decision-making:

- If the value of Asymp. Sig. (2-tailed) $> \alpha$ with $\alpha = 0{,}05$, then H_0 is accepted, H_1 is rejected.
- If the value of Asymp. Sig. (2-tailed) $< \alpha$ with $\alpha = 0{,}05$, then H_0 is rejected, H_1 is accepted.

The value of Asymp.Sig. (2-tailed) for the *Pretest of the* experimental class and control class is greater than 0.05 (0,365 > 0,05). This means that H0 is accepted, H1 is rejected, so there is no significant difference between the average creative thinking skills of experimental and control class students.

Posttest **Data Normality Test**

The normality test of the posttest data that has been carried out in both classes can be seen in the following:

Tests of Normality

	Kelas	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Kemampuan Berfikir Kreatif	Posttest Eksperimen	,177	20	,101	,881	20	,019
	Posttest Kontrol	,196	19	,053	,924	19	,134

a. Lilliefors Significance Correction

Figure 4. Normality Test Results of Posttest Data for Experimental and Control Classes

On the basis of decision-making:

- If the significance value (sig.) $> \alpha$ with α = 0,05, then the data is normally distributed**.**
- If the significance value (sig.) $< \alpha$ with α = 0,05, then the data is not normally distributed.

ISSN: 2620-4129
E-ISSN: 2621-3885

Based on the table above, it can be obtained that the *Shapiro-Wilk significance* value for the experimental class *Posttest* data is smaller than 0.05 (0.019). While the *Shapiro-Wilk* significance value for the control class *Posttest* data is greater than 0.05 (0.134). So it can be concluded that the data is not normally distributed, because one of them is not normally distributed, namely the experimental class, so overall the data is not normally distributed.

Mann-Whitney U Test (U-Test) Posttest

The Mann-Whitney U test (U-Test) of the posttest data that has been carried out in both classes can be seen in the following:

Test Statistics[a]

	Kemampuan Berfikir Kreatif
Mann-Whitney U	75,000
Wilcoxon W	265,000
Z	-3,255
Asymp. Sig. (2-tailed)	,001
Exact Sig. [2*(1-tailed Sig.)]	,001[b]

a. Grouping Variable: Kelas

b. Not corrected for ties.

Figure 5. Mann-Whitney U Test Results Posttest of Experimental and Control Classes

On the basis of decision-making:

- If the value of Asymp. Sig. (2-tailed) > α with α = 0,05 , then H0 is accepted, H1 is rejected.
- If the value of Asymp. Sig. (2-tailed) < α with α = 0,05, then H0 is rejected, H1 is accepted.

Based on the table above, the Asymp.Sig. (2-tailed) for *Posttest of* experimental class and control class is smaller than 0.05 (0,001 < 0,05). This means that H0 is rejected, H1 is accepted, so there is a significant difference between the average creative thinking ability of experimental and control class students.

3.2 Discussion

This study aims to see the effect of Problem-Based Learning model on mathematical problem solving ability of students in class X SMK Kesehatan. The decision taken from this research is based on descriptive analysis and inferential analysis. The results of descriptive statistical analysis showed that the average Pretest score of the experimental class was 31.95, while the Posttest score reached 70.05. Meanwhile, the average Pretest score of the control class was 29.37, and the Posttest score was 63.26.

Furthermore, the average increase in creative thinking skills in the experimental class reached 38.1, while the increase in the control class was only 33.89. This shows that the increase in creative thinking skills in the experimental class is higher than the control class. Thus, it can be concluded that the Problem-Based Learning model has a significant positive effect on students' creative thinking skills in class X SMK Kesehatan.

The one of the models that can be used to hone students' mathematical creative thinking skills is the *Problem Based Learning* Model [48]. The *Problem Based Learning* model challenges students to learn how to learn, working in groups to find solutions to various problems. In addition, Arends defines *Problem Based Learning* as a learning model where students are trained to be able to compile their own knowledge, foster inquiry and higher-level skills, empower students and increase their self-confidence. Meanwhile, Hmelo-Silver and Eberbac suggest that *Problem Based Learning is* a learning model that trains students to construct specific abilities to solve a problem independently based on experience or habit. Thus, applying the *Problem Based Learning* model to mathematics learning is expected to develop students' creative thinking skills to solve problems using various solution strategies.

The results of the inferential analysis of the posttest values of the experimental class and control class obtained the value of Asymp.Sig. (2-tailed) for the *Posttest of the* experimental class and control class is smaller than 0.05 (0,001 < 0,05). This means that H0 is rejected, H1 is accepted, so there is a significant difference between the average creative thinking ability of experimental and control class students. This means that there is an effect of the *Problem Based Learning* (PBL) model on the creative thinking ability of students in class X SMK Health. So it can be concluded that there is an effect of the Problem-Based Learning model on the mathematical creative thinking ability of students of SMK Kesehatan Bengkalis.

4. CONCLUSION

Based on the results of research and data analysis that has been carried out, Asymp.Sig. (2-tailed) (0,001 < 0,05), then H0 is rejected, H1 is accepted, so it can be concluded that there is an effect of the *Problem Based Learning* (PBL) learning model on the creative thinking ability of class X students of SMK Kesehatan Bengkalis.

REFERENCES

[1] Muhamad Yunus, Mizan Abrory, Zafrullah, Dedek Andrian, and David Maclinton, "The Effectiveness of Macromedia Flash Digital Media in Improving Students' Mathematics Reasoning," *Math. Res. Educ. J.*, vol. 6, no. 1, pp. 14–20, 2022, doi: 10.25299/mrej.2022.vol6(1).9013.

[2] M. Baran, M. Baran, F. Karakoyun, and A. Maskan, "The influence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills," *J. Turkish Sci. Educ.*, vol. 18, no. 4, pp. 798–815, 2021.

[3] V. Giaconi, G. Gómez, D. Jiménez, B. Gareca, F. D. del Fierro, and M. L. Varas, "Initial Diagnostic Assessment in Pre-Service Teacher Training in Chile and its Relationship With Institutional Contexts," *Pensam. Educ.*, vol. 59, no. 1, 2022, doi: 10.7764/PEL.59.1.2022.4.

[4] Z. Zetriuslita, E. Istikomah, and N. Nofriandi, "Improving Students' Mathematics Communication Ability Through Geogebra," *Pedagog. J. Pendidik.*, vol. 10, no. 2, pp. 113–126, 2021, doi: 10.21070/pedagogia.v10i2.1266.

[5] A. M. Ramadhani and H. Retnawati, "Computational Thinking and its Application in School: A Bibliometric Analysis (2008-2023)," in *International Conference on*

ISSN: 2620-4129
E-ISSN: 2621-3885

Current Issues in Education (ICCIE 2023), 2024, pp. 329–338, [Online]. Available: https://doi.org/10.2991/978-2-38476-245-3_35.
[6] A. M. Ramadhani, N. Y. B. Yakob, R. T. Ayuni, Z. Zafrullah, and A. A. Bakti, "TRENDS IN IMPLEMENTATION OF GAME USE AS LEARNING AT PRIMARY SCHOOLS LEVEL IN SCOPUS DATABASE: A BIBLIOMETRIC ANALYSIS," *J. Penyelid. Sains Sos.*, vol. 7, no. 23, 2024.
[7] S. Ulwiyah, "Rasch Model Analysis on Mathematics Test Instruments: Biblioshiny (1983-2023)," *Math. Res. Educ. J.*, vol. 7, no. 2, pp. 1–13, 2023, [Online]. Available: https://doi.org/10.25299/mrej.2023.vol7(2).14550.
[8] Z. Zafrullah, A. Fitriani, A. M. Ramadhani, and S. M. N. Hidayah, "Transformasi Adobe Flash dalam Dunia Pendidikan: Analisis Bibliometrik (2006-2023)," *Indo-MathEdu Intellectuals J.*, vol. 4, no. 3, pp. 1652–1666, 2023, [Online]. Available: https://doi.org/10.54373/imeij.v4i3.387.
[9] Z. Zafrullah, Y. K. Sembiring, N. Ramadana, R. N. Gunawan, and K. Kusumawardhani, "Research Trends on the Use of Artificial Intelligence in Educational Environments in Southeast Asia on Scopus Database: A Bibliometric Analysis (2014-2024)," *Innov. J. Soc. Sci. Res.*, vol. 4, no. 5, pp. 8972–8989, 2024.
[10] D. Andrian, A. Wahyuni, S. Ramadhan, F. R. E. Novilanti, and Zafrullah, "Pengaruh Pembelajaran Kooperatif Tipe STAD Terhadap Peningkatan Hasil Belajar, Sikap Sosial, dan Motivasi Belajar," *Inomatika*, vol. 2, no. 1, pp. 65–75, 2020, doi: 10.35438/inomatika.v2i1.163.
[11] S. Hadi, S. Maisaroh, A. Hidayat, and D. Andrian, "An Instrument Development to Evaluate Teachers' Involvement in Planning the Schools' Budgeting at Elementary Schools of Yogyakarta Province.," *Int. J. Instr.*, vol. 15, no. 2, 2022.
[12] D. Andrian and L. A. Effendi, "Instrument and evaluation of students' involvement in learning Mathematics in 21-century skills at senior high schools of Riau province," *J. Penelit. dan Eval. Pendidik.*, vol. 27, no. 1, p. 14, 2023.
[13] N. Nofriyandi *et al.*, "Peningkatan Kemampuan Desain Media Pembelajaran Matematika Berbasis Education For Sustainable Development Guru," *Community Educ. Engagem. J.*, vol. 2, no. 2, pp. 21–26, 2021.
[14] Z. Zafrullah, Z. S. Ibrahim, R. Ariawan, S. Ulwiyah, and R. T. Ayuni, "Research on Madrasas in International Publications: Bibliometric Analysis with Vosviewer," *Compet. J. Educ.*, vol. 3, no. 2, pp. 116–127, 2024, [Online]. Available: https://doi.org/10.58355/competitive.v3i2.93.
[15] D. Andrian, K. Amri, R. K. Nugraheni, A. H. Nasution, and Azmansyah, "Analysis of Creative Economic Situation in Pekanbaru: Statistical Analysis and Word Cloud," in *International conference on smart computing and cyber security: strategic foresight, security challenges and innovation*, 2023, pp. 169–179.
[16] S. Hamdi, N. M. Murdiyani, M. Fauzan, H. Djidu, E. Chrisdiyanto, and Z. Zafrullah, "Developing an assessment instrument for strengthening the Pancasila student profile in web-based middle school mathematics teaching," *J. Elem.*, vol. 10, no. 3, pp. 479–500, 2024.
[17] Z. Zafrullah, R. N. Gunawan, H. Haidir, and A. M. Ramadhani, "IMPLEMENTASI PENGGUNAAN KEMAMPUAN COMPUTATIONAL THINKING PADA SEKOLAH ANAK-ANAK: ANALISIS BIBLIOMETRIK (2014-2024)," *J. Binagogik*, vol. 11, no. 2, pp. 201–225, 2024.
[18] M. M. H. Isfahani, M. Q. Zuhriawan, and H. Ashoumi, "Krulik and Rudnick's Perspective: Analysis of Reflective Thinking Ability of Students," *Sch. Soc. Lit. Study*

Educ., vol. 4, no. 2, pp. 101–108, 2024.
[19] A. D. Safirah, N. Nasution, and U. Dewi, "Analysis of the Development Needs of HOTS-Based Electronic Student Worksheets with Culturally Responsive Teaching Approach in Elementary Schools," *IJORER Int. J. Recent Educ. Res.*, vol. 5, no. 1, pp. 243–256, 2024.
[20] J. Sultan, S. Suyanto, and Z. S. Ibrahim, "The Relationship between Critical Thinking and Learning Outcomes in Science and Mathematics Subjects Reviewed from Meta Analysis," *J. Penelit. Pendidik. IPA*, vol. 9, no. 8, pp. 493–498, 2023, [Online]. Available: 10.29303/jppipa.v9i8.3862.
[21] N. Gustina, "Integration of character education in citizenship education learning to develop the character of elementary school students," *Int. J. Students Educ.*, pp. 390–397, 2024.
[22] D. Feriana and T. Ulfatun, "The role of school culture in shaping a positive learning environment," *Cetta J. Ilmu Pendidik.*, vol. 7, no. 1, pp. 126–131, 2024.
[23] Z. Zafrullah, Z. Zetriuslita, S. Rezeki, and S. Suripah, "Development of Interactive Multimedia Learning Mathematics Learning Media using Adobe Flash CS6," *Math. Res. Educ. J.*, vol. 8, no. 1, pp. 17–28, 2024, [Online]. Available: https://doi.org/10.25299/mrej.2024.vol8(1).14499.
[24] J. W. Sitopu, M. Khairani, M. Roza, L. Judijanto, and A. Aslan, "The Importance Of Integrating Mathematical Literacy In The Primary Education Curriculum: A Literature Review," *Int. J. Teach. Learn.*, vol. 2, no. 1, pp. 121–134, 2024.
[25] K. Lu, H. H. Yang, Y. Shi, and X. Wang, "Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment," *Int. J. Educ. Technol. High. Educ.*, vol. 18, pp. 1–13, 2021.
[26] D. Andrian, S. Nurhalimah, and F. Loska, "Problem Based-Learning Performance in Improving Students' Critical Thinking, Motivation, Self-Efficacy, And Students' Learning Interest," *Mosharafa J. Pendidik. Mat.*, vol. 13, no. 1, pp. 259–272, 2024.
[27] D. Andrian *et al.*, "Implementasi Formatif Dan Sumatif Assessmen Dalam Meningkatkan Kualitas Pembelajaran Di Kelas," *J. Pengabdi. Masy. Bangsa*, vol. 2, no. 3, pp. 479–485, 2024.
[28] B. Aidoo, V.-M. Vesterinen, M. A. Macdonald, B. Gísladóttir, and S. Pétursdóttir, "Perceptions of Ghanaian Student Teachers on Benefits and Challenges of the Flipped Classroom: A Case Study.," *Contemp. Educ. Technol.*, vol. 14, no. 4, 2022.
[29] P. Cabrera-Solano, C. Ochoa-Cueva, and L. Castillo-Cuesta, "Implementing the Engage, Study, Activate Approach Using Technological Tools in Higher Education," *Int. J. Learn. Teach. Educ. Res.*, vol. 22, no. 1, pp. 268–282, 2023.
[30] D. C. Owens, T. D. Sadler, A. T. Barlow, and C. Smith-Walters, "Student motivation from and resistance to active learning rooted in essential science practices," *Res. Sci. Educ.*, vol. 50, pp. 253–277, 2020.
[31] M. Ferreira, B. Martinsone, and S. Talić, "Promoting sustainable social emotional learning at school through relationship-centered learning environment, teaching methods and formative assessment," *J. Teach. Educ. Sustain.*, vol. 22, no. 1, pp. 21–36, 2020.
[32] M. Sadoughi and S. Y. Hejazi, "Teacher support and academic engagement among EFL learners: The role of positive academic emotions," *Stud. Educ. Eval.*, vol. 70, p. 101060, 2021.
[33] A. Derakhshan, J. Fathi, M. Pawlak, and M. Kruk, "Classroom social climate, growth language mindset, and student engagement: The mediating role of boredom in

learning English as a foreign language," *J. Multiling. Multicult. Dev.*, vol. 45, no. 8, pp. 3415–3433, 2024.
[34] Z. Zafrullah, S. Suyanto, A. Wahyuni, R. T. Ayuni, and F. R. E. Novilanti, "Development of Android-based Learning to Improve Computational Thinking Skills in Junior High School," *J. Cendekia J. Pendidik. Mat.*, vol. 7, no. 2, pp. 1309–1320, 2023, [Online]. Available: https://doi.org/10.31004/cendekia.v7i2.2239.
[35] M. L. Hakim and M. Angga, "ChatGPT Open AI: Analysis of Mathematics Education Students Learning Interest," *J. Technol. Glob.*, vol. 1, no. 01, pp. 1–10, 2023, [Online]. Available: https://penaeducentre.com/index.php/JTeG/article/view/35.
[36] A. Wahyuni, Y. S. Kusumah, B. A. P. Martadiputra, and Z. Zafrullah, "Tren penelitian kemampuan pemecahan masalah pada pendidikan matematika: Analisis bibliometrik," *JPMI (Jurnal Pembelajaran Mat. Inov.*, vol. 7, no. 2, pp. 337–356, 2024, doi: 10.22460/jpmi.v7i2.22329.
[37] Z. Zafrullah and Z. Zetriuslita, "Learning interest of seventh grade students towards mathematics learning media assisted by Adobe Flash CS6," *Math Didact. J. Pendidik. Mat.*, vol. 7, no. 2, pp. 114–123, Aug. 2021, doi: 10.33654/math.v7i2.1272.
[38] O. A. Desmet, "Nurturing Changemakers: Harnessing the Power of Service-Learning Pedagogy for Transformational Creativity," in *Transformational Creativity: Learning for a Better Future*, Springer, 2024, pp. 103–119.
[39] L. Li, S. M. Ismail, I. Patra, and D. Lami, "Not a passive learner but an active one: a focus on the efficacy of philosophy-based language instruction and its consequences on EFL learners' critical thinking, engagement, and academic achievement," *BMC Psychol.*, vol. 12, no. 1, pp. 1–19, 2024.
[40] J. Moon, L. McNeill, C. T. Edmonds, S. K. Banihashem, and O. Noroozi, "Using learning analytics to explore peer learning patterns in asynchronous gamified environments," *Int. J. Educ. Technol. High. Educ.*, vol. 21, no. 1, p. 45, 2024.
[41] L. Marcinauskas, A. Iljinas, J. Čyvienė, and V. Stankus, "Problem-based learning versus traditional learning in physics education for engineering program students," *Educ. Sci.*, vol. 14, no. 2, p. 154, 2024.
[42] L. Ma *et al.*, "Enhancing Surgical Nursing Student Performance: Comparative Study of Simulation-Based Learning and Problem-Based Learning," *J. Multidiscip. Healthc.*, pp. 991–1005, 2024.
[43] A. Suradika, H. I. Dewi, and M. I. Nasution, "Project-based learning and problem-based learning models in critical and creative students," *J. Pendidik. IPA Indones.*, vol. 12, no. 1, pp. 153–167, 2023.
[44] D. M. Anggraeni, B. Prahani, N. Suprapto, N. Shofiyah, and B. Jatmiko, "Systematic review of problem based learning research in fostering critical thinking skills," *Think. Ski. Creat.*, p. 101334, 2023.
[45] M. Ramzan, Z. K. Javaid, and A. A. Ali, "Perception of students about collaborative strategies employed by teachers for enhancing English vocabulary and learning motivation," *Pakistan J. Law, Anal. Wisdom*, vol. 2, no. 02, pp. 146–158, 2023.
[46] N. Hidayati, S. Zubaidah, and S. Amnah, "Effective learning model bases problem based learning and digital mind maps to improve student's collaboration skills," *Int. J. Eval. Res. Educ.*, vol. 12, no. 3, pp. 1307–1314, 2023.
[47] A. Ni'mah, E. S. Arianti, S. Suyanto, S. H. P. Putera, and A. Nashrudin, "Problem-Based Learning (PBL) Methods Within An Independent Curriculum (A Literature Review)," *Sintaksis Publ. Para ahli Bhs. dan Sastra Ingg.*, vol. 2, no. 4, pp. 165–174, 2024.

[48] A. J. Khoiriyah and H. Husamah, "Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students," *JPBI (Jurnal Pendidik. Biol. Indones.*, vol. 4, no. 2, pp. 151–160, 2018.

ISSN: 2620-4129
E-ISSN: 2621-3885