

IMPLEMENTATION OF SCAFFOLDING STRATEGY TO IMPROVE CHEMICAL LITERATION CAPABILITIES AND SELF-EFFICACY THROUGH USE OF THE PROBLEM-BASED LEARNING MODEL AT COLLOID MATERIAL

Harsono Hammasa^{1*}, Iriani Bakti², Muhammad Kusasi²

¹Chemistry Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Indonesia

Jl. Dr. Setiabudhi Nomor 229 Bandung 40154, Jawa Barat, Indonesia

²Chemistry Education Study Program, Faculty of Teacher Training and Education, Universitas Lambung Mangkurat

Jl. Brigjen H. Hasan Basry, Banjarmasin 70123, Kalimantan Selatan, Indonesia

*email: drharsono368@gmail.com

Abstract. The scaffolding strategy is designed to address difficulties in understanding materials. By using scaffolding, it is possible to improve chemical literacy and self-efficacy. The teaching of colloidal material has not represented abstract material adequately. Therefore, to enhance chemical literacy and self-efficacy, a student-centered learning model is needed, namely the problem-based learning (PBL) model. This study aims to determine the differences in chemical literacy and self-efficacy in the scaffolding strategy with the PBL model, the relationship between chemical literacy and self-efficacy, and student responses to the scaffolding strategy with the PBL model. The research method used was quasi-experimental with a pretest-posttest non-equivalent control group design. Purposive sampling was employed for sample selection. The study used descriptive and inferential analysis, comparing dependent variables in the experimental class using the scaffolding strategy with the PBL model and the control class using the PBL model, with a sample of 73 students. The results indicate a significant difference in chemical literacy and self-efficacy between the scaffolding strategy with the PBL model and a positive response from students in terms of chemical literacy and self-efficacy after treatment. The Pearson correlation (r_{xy}) between chemical literacy and self-efficacy was 0.674, indicating a strong correlation. The R^2 value was 0.454, meaning that self-efficacy contributes 45.4% to chemical literacy. Students showed a positive response to the scaffolding strategy with the PBL model compared to without the scaffolding strategy. Therefore, the implementation of the scaffolding strategy with the PBL model can enhance chemical literacy and self-efficacy by providing students with assistance in understanding materials and problem-solving. The application of the scaffolding model in PBL activities should be modified using supportive media with characteristics similar to those in this study.

Keywords: scaffolding, problem based learning, chemical literacy, self-efficacy, colloid.

INTRODUCTION

Chemistry is a scientific discipline aimed at developing students' thinking skills and scientific attitudes, enabling them to comprehend chemical concepts to solve problems in learning (Álvarez-Huerta et al., 2022). Effective learning occurs when it provides meaning to students. Meaningfulness in chemistry learning can be achieved through good chemical literacy skills (Ad'hiya & Laksono, 2018). The low quality of chemistry learning outcomes is also attributed to school learning processes that inadequately train literacy skills. The current state of students' chemistry literacy

in Indonesia is a significant educational issue (Yuriza et al., 2018), with research finding Indonesia ranked 4th from the bottom in TIMSS (Trends in International Mathematics and Science Study) (Ad'hiya & Laksono, 2018). This indicates a lack of conceptual or reasoning understanding of chemistry among students. The importance of chemical literacy is taken seriously by other countries such as the United States and Australia (Danczak et al., 2017).

The results of these studies explain why students find it challenging to derive meaning from the provided learning materials, leading to difficulties in relating subject concepts to real-world problem-solving applications. The struggle with learning chemistry negatively impacts the overall learning outcomes (Jarvis & Baloyi, 2020). Therefore, self-efficacy is required as confidence in learning chemistry materials. Self-efficacy is an individual's belief in their ability to perform a task successfully (Holzer et al., 2023). Success in mastering material is influenced by one's belief, as beliefs guide behavior in a way that makes them a reality. Holzer et al., (2023) in their research stated that there is a positive and significant relationship between students' self-efficacy and their chemistry learning outcomes. However, Indonesian students tend to have low self-efficacy potential, as students with low self-efficacy may doubt their abilities, feel uncomfortable, easily give up, act slowly, and become stressed when facing challenging tasks.

Based on this explanation, it is crucial to possess both chemical literacy skills and self-efficacy when studying chemistry. Therefore, to improve students' chemical literacy and self-efficacy, a learning model is needed (Andersen & Rösiö, 2021). The suggested learning model is Problem-Based Learning (PBL). PBL is a teaching model that engages students actively in the learning process, enhancing problem-solving skills and critical thinking, ultimately improving chemical literacy and self-efficacy (Kolmos et al., 2020).

Efforts to enhance chemical literacy and self-efficacy can be achieved using teaching techniques, methods, and approaches that require students to master material without relying heavily on the teacher. One such approach is the scaffolding strategy (Green & Dillard, 2021). *Scaffolding* as defined by Awadelkarim (2021) involves providing individuals with significant assistance gradually at the beginning of learning, then reducing that assistance, and giving students the opportunity to take on increasing responsibility once they can work independently. Jarvis & Baloyi (2020) stated that the scaffolding strategy is designed to address difficulties in understanding materials according to individual abilities, thereby improving students' understanding of the presented material. The scaffolding strategy applied in the PBL model is expected to clarify the concept of colloids. Learning with the scaffolding strategy is highly appropriate for everyday life. One chemistry topic closely related to controversial issues is the colloid material (Sari et al., 2019).

Colloid material significantly influences the environment, such as purifying cloudy water, identifying DNA, the blood dialysis process, and many other colloidal applications in life (Sari et al., 2022). Colloid material is abstract and requires not only deep understanding but also the ability to solve chemical problems. Therefore, the scaffolding strategy with the PBL model is highly beneficial in implementing colloid learning (Herdiawan et al., 2019).

Considering the above, the researcher is interested in addressing the problem of improving chemical literacy and self-efficacy by conducting quasi-experimental research on colloid materials using the problem-based learning model. The aim is also to determine how students respond to the use of scaffolding strategies in chemistry learning, particularly in colloid materials.

RESEARCH METHOD

The research employed a quasi-experimental design using a pretest-posttest non-equivalent control group design. This design involved two classes: the control class and the experimental class. The impact of this design on the dependent variable would be tested by comparing the conditions of the dependent variable in the experimental class using the problem-based learning model with scaffolding strategy and the control class using the problem-based learning model. In this design, both the experimental and control classes were given a pre-test before the learning process to assess students' initial abilities before applying the treatment. After the learning process, both the experimental and control classes were given a post-test. The research design overview can be seen in Table 1.

Table 1. Pre-test and post-test non-equivalent group design

Class	Pre-test	Treatment	Post-test
Control	O ₁	X ₁	O ₂
Experimental	O ₃	X ₂	O ₄

Information:

- O₁ = pre-test score for the control class
- O₃ = pre-test score for the experimental class
- O₂ = post-test score for the control class
- O₄ = post-test score for the experimental class
- X₁ = learning using problem-based learning
- X₂ = learning using problem-based learning with scaffolding strategy

The research was conducted at IT UKHUWAH High School in Banjarmasin, located at Jl. Bumi Mas Raya Pemurus Baru, comp. Bumi Handayani 12A km. 4.5, South Banjarmasin. The research sample consisted of 73 students. The sampling technique used in this research was purposive sampling, which involves selecting samples based on specific considerations that make them suitable for the study. The research utilized two data analysis techniques: descriptive analysis and inferential analysis. Descriptive analysis used descriptive statistics to analyze chemical literacy, self-efficacy, and student response questionnaires. Meanwhile, inferential analysis aimed to test the hypotheses presented, determining whether there were differences or not (Taherdoost, 2022).

RESEARCH RESULTS AND DISCUSSION

Chemical Literacy Analysis

Chemical literacy is related to students' ability not only to understand acquired lessons but also to apply them in daily life based on the knowledge gained. In this research, chemical literacy tests were conducted twice in each class using the PBL model with scaffolding strategy for colloidal materials in the experimental class and using the PBL model in the control class. Additionally, a pre-test and post-test were administered. The results of the pre-test and post-test for the experimental and control classes can be seen in Figure 1.

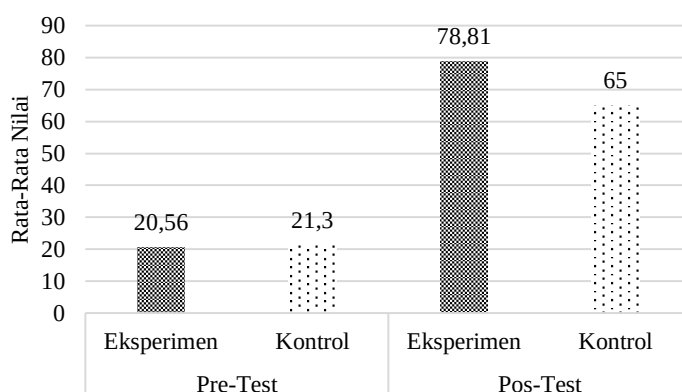


Figure 1. Average scores of students' chemical literacy

Based on Figure 1, it is apparent that there is little difference in the pre-test scores between the experimental and control classes. The calculated $t_{\text{value}} < t_{\text{table}}$, indicating that the null hypothesis (H_0) is accepted, meaning there is no significant difference in chemical literacy between the experimental and control classes before the learning process. Both classes received different treatments during the learning process, with the experimental class using the PBL model with scaffolding strategy, while the control class used the PBL model.

The average score for chemical literacy in the experimental class is higher than that in the control class, specifically 78.81 for the experimental class and 65 for the control class. This difference is attributed to the application of the scaffolding strategy in the experimental class. Consistent with research findings (Yuriza et al., 2018) the use of the PBL model improves students' chemical literacy skills.

The hypothesis test indicates a significant difference in chemical literacy between the experimental and control classes. Therefore, it can be stated that the PBL learning model with scaffolding strategy has a positive impact on students' chemical literacy concerning colloidal materials. The quality difference in the improvement of students' chemical literacy between the experimental and control classes can be observed from the average N-gain values in Table 2.

Table 2. Average values of chemical literacy in experimental and control classes

Class	<g>	Category
Experimental	0,74	High
Control	0,55	Medium

Students in the experimental class fall into the high category, while those in the control class fall into the medium category. The average N-gain value for the experimental class is 0.74, while for the control class, it is 0.55. Thus, it can be said that the PBL model with the scaffolding strategy is more effective in improving students' chemical literacy in this research. The study is also based on the achievement level of each chemical literacy indicator in the experimental and control classes, which shows differences. For further clarity, refer to Table 3.

Table 3. Achievement of chemical literacy indicators in pre-test and post-test

No	Chemical Literacy Indicator	Percentage of Understanding Level of Chemical Literacy Indicator (%)	
		Experimental Class	Control Class
1	Reviewing and applying knowledge appropriately	75,00	59,26
2	Identifying and generalizing images	80,56	55,56
3	Scientifically proposing from questions	75,93	71,30
4	Identifying evidence of scientific statements	85,19	78,70
5	Analyzing, interpreting, and drawing conclusions	82,41	60,19

The first indicator shows an increase in chemical literacy for the experimental class by 75.00% and the control class by 59.26%. This indicates that the experimental class is better at reviewing and applying knowledge appropriately. The questions measuring this indicator are relatively easy, and most students can answer them correctly, as reflected in the percentage.

For the second indicator, there is a notable increase in chemical literacy, with 80.56% for the experimental class and 55.56% for the control class. There is a significant difference between the experimental and control classes in this indicator, indicating that the experimental class is more capable of identifying, using, and generalizing images. The questions measuring this indicator are moderate, but most students in both classes can answer them well.

The third indicator involves proposing a scientific way to explore problems. The average score increase for the experimental class is 75.93%, while for the control class, it is 71.30%. This shows that the experimental class is more capable of proposing a scientific way to explore problems. The questions measuring this indicator are difficult, but the experimental class can solve them effectively.

The fourth indicator shows an increase of 85.19% for the experimental class and 78.70% for the control class. The increase in this indicator is quite high for both classes because the questions measuring this indicator are moderate.

The fifth indicator demonstrates an improvement in chemical literacy skills, with 82.41% for the experimental class and 60.19% for the control class. The increase in chemical literacy for the experimental class is greater than that for the control class. This indicates that students in the experimental class are more capable of analyzing, interpreting, and drawing conclusions. The increase in this indicator is significant because the questions are difficult and require concentration to analyze the provided discourse.

The research results indicate that the use of the PBL model with the scaffolding strategy helps students engage directly in the learning process. Consequently, students can relate the knowledge gained during the learning process to phenomena occurring in daily life. According to Sari et al., (2022) direct involvement makes it easier for students to find answers to investigated problems.

Self-Efficacy Analysis

In this study, students' self-efficacy was measured concerning learning using the scaffolding strategy with the problem-based learning model. The homogeneity test results for students' self-efficacy before learning in the experimental and control classes indicated homogeneity. This suggests that there was no significant difference

in self-efficacy before learning between the experimental and control classes. The average values for students in the experimental class were 66.72, while for the control class, they were 63.54. All students were categorized as having good self-efficacy, as shown in Table 4.

Table 4. Average pre-test and post-test self-efficacy scores

Score	Experimental Class		Control Class	
	Pre-test	Post-test	Pre-test	Post-test
The Lowest	44	61,33	45,33	61,33
The Highest	84	94,67	82,67	85,33
Average	66,72	77,49	63,54	72,32

The average post-test self-efficacy score for the experimental class was higher than that for the control class, with values of 77.49 for the experimental class and 72.32 for the control class. Based on the results of inferential analysis using the t-test, there was a difference in students' self-efficacy between the experimental and control classes. The variation in achievement was attributed to the implementation of the scaffolding strategy with the problem-based learning model. The application of this strategy made students more actively participate, leading to increased self-confidence. This aligns with Awadelkarim's research (2021), which states that the application of the scaffolding learning strategy significantly affects student outcomes, including chemical literacy and self-efficacy.

Table 5. T-test results for pre-test and post-test self-efficacy data

Result	Class	Db	X	SD ²	t-value	t-table 5%	Conclusion
Pre-Test	Experimental	71	68,15	87,40	1,98	1,99	Insignificant
	Control		63,82	80,83			
Post-Test	Experimental	71	80,80	51,26	5,12	1,99	Significant
	Control		72,31	45,69			

The average post-test self-efficacy score after learning in the experimental class was greater than that in the control class, with values of 80.80 and 72.31, respectively. Based on the t_{value} and t_{table} (where $t_{\text{value}} > t_{\text{table}}$, $5.123 > 1.993$), it can be concluded that H_0 is rejected, indicating a significant difference between the average self-efficacy scores of students in the experimental and control classes after the treatment.

Fundamentally, students already possessed self-efficacy at a reasonably good average level. No student had low self-efficacy. This ability was inherent in each student, and there was no guidance to explore it, which could be beneficial in the global competitive environment. According to research conducted by (Schneider et al., 2022), students with confidence in learning significantly influence their learning outcomes. Students with good self-efficacy tend to have higher average learning outcomes than those in the fairly good category. This is because of their strong belief in learning and the effort to think critically to understand the learning concept.

The self-efficacy questionnaire data obtained before and after learning were then transformed into N-gain data to determine the extent to which students experienced an increase in self-efficacy after participating in colloidal material learning. N-gain data for the experimental and control classes can be seen in Table 6.

Table 6. Experimental and control self-efficacy N-gain

Interval	Categorization	Experimental	Control
		Frequency	Frequency
$\langle g \rangle \geq 0,7$	High	5	0
$0,7 > \langle g \rangle \geq 0,3$	Medium	14	10
$\langle g \rangle < 0,3$	Low	16	28

The obtained N-gain values were then interpreted according to the criteria presented by N-gain, as shown in Table 7.

Table 7. Interpretation of self-efficacy in N-gain

Class	N-gain	Category
Experimental	0,36	Sedang
Control	0,22	Rendah

Based on the N-gain values in Table 7, it can be observed that the experimental class has a higher value compared to the control class. The experimental class experienced a greater increase in self-efficacy than the control class after receiving colloidal learning with the scaffolding strategy in the PBL model.

Colloidal material has conceptual characteristics, requiring a good understanding of the concept for effective learning. To comprehend this material well, students must possess high self-efficacy. Students with strong self-belief tend to exert more effort to achieve learning goals. This aligns with the opinion of Holzer et al., (2023), stating that an individual's success in mastering material is influenced by their beliefs. Beliefs shape one's behavior and drive them to achieve their goals to become a reality.

Students with high self-efficacy are inclined to persevere and strive to understand the learning material to the best of their ability, as evidenced by their active participation in class. Accordingly, students with high self-efficacy can perform tasks according to situational demands with the expectation of good results (Liu et al., 2023).

Data Result of Product Moment Correlation

This analysis aims to determine the relationship between chemical literacy and self-efficacy. The obtained r-value is then compared with the r-table value.

Table 8. Results of the correlation coefficient for the experimental and control classes

Class	Obtained Value		Conclusion
Experimental	r-value	0,59	Positive correlation with a moderate strength
	r-table	0,33	
	r-value	4,22	Significant correlation
	r-table	1,99	
Control	r-value	0,34	Positive correlation with a low strength
	r-table	0,32	
	r-value	2,21	Significant correlation
	r-table	1,99	

According to the correlation analysis results, the obtained r_{value} is 0.59 for the experimental class. This value is then compared with the r_{table} product moment with a significance level of 5% and N of 35, resulting in an r_{table} value of 0.33. As the r_{value} (0.59) > r_{table} (0.33), it can be concluded that there is a positive relationship

between chemical literacy and self-efficacy. The interpretation of the r_{value} (0.59) indicates a moderate relationship between chemical literacy and students' self-efficacy. Further significance tests of the product moment correlation were conducted to determine the significance of the relationship between chemical literacy and students' self-efficacy in the experimental class. According to the analysis results, the obtained r_{value} (4.22) > r_{table} (1.69), concluding a significant positive relationship between chemical literacy and self-efficacy in the experimental class.

In the control class, with an r_{value} (0.34) > r_{table} (0.32), there is a positive relationship between chemical literacy and self-efficacy. The interpretation of the r_{value} (0.34) indicates a low relationship between chemical literacy and students' self-efficacy. Moreover, there is a significant relationship with an r_{value} (2.21) > r_{table} (1.99). Hypothesis testing was also conducted to determine acceptance or rejection regarding the relationship between chemical literacy and the four aspects of self-efficacy.

Table 9. Product moment correlation test result

Variable	Sig.(2-tailed)	Pearson Correlation	R ²	Conclusion
Chemical literacy with self-efficacy	5×10^{-6}	0,674	0,454	Significant Correlation
Self-efficacy aspect of coping with situations with chemical literacy	$2,9 \times 10^{-5}$	0,630	0,397	Significant Correlation
Self-efficacy aspect of motivation with chemical literacy	0,001	0,539	0,291	Significant Correlation
Self-efficacy aspect of target achievement with chemical literacy	$6,3 \times 10^{-5}$	0,609	0,371	Significant Correlation
Self-efficacy aspect of problem-solving with chemical literacy	$4,9 \times 10^{-5}$	0,615	0,379	Significant Correlation

In Table 9, the significance test values of the correlation results for all self-efficacy variables based on chemical literacy aspects consistently show values smaller than 0.05. This indicates that each aspect of self-efficacy has a positive and significant relationship with chemical literacy.

In addition to r_{xy} , the coefficient of determination (R square) or often symbolized as R^2 was also obtained. The R^2 value is used to see how much contribution the independent variable (X) gives to the dependent variable (Y). The R^2 value is the square of the r_{xy} value.

For the relationship between the self-efficacy variable of coping with situations and chemical literacy, an R^2 of 0.397, or 39.7%, was obtained. This means that the self-efficacy aspect of coping with situations influences chemical literacy by 39.7%, while the remaining portion ($100\% - 39.7\% = 60.3\%$) is influenced by other variables outside the regression model. For the relationship between the self-efficacy variable of motivation and target achievement with chemical literacy, an R^2 of 0.291, or 29.1%, was obtained. This indicates that the self-efficacy aspect of motivation influences chemical literacy by 29.1%. In the relationship between the self-efficacy variable of achieving targets and chemical literacy, an R^2 of 0.371, or 37.1%, was obtained. This means that the self-efficacy aspect of achieving targets influences learning outcomes by 37.1%. Lastly, in the relationship between the self-efficacy variable of problem-solving and chemical literacy, an R^2 of 0.379, or 37.9%, was obtained. This means that the self-efficacy aspect of problem-solving influences chemical literacy by 37.9%.

For the relationship between the self-efficacy variable of coping with situations and chemical literacy, an R^2 of 0.397, or 39.7%, was obtained. This means that the self-efficacy aspect of coping with situations influences chemical literacy by 39.7%, while the remaining portion ($100\% - 39.7\% = 60.3\%$) is influenced by other variables outside the regression model. For the relationship between the self-efficacy variable of motivation and target achievement with chemical literacy, an R^2 of 0.291, or 29.1%, was obtained. This indicates that the self-efficacy aspect of motivation influences chemical literacy by 29.1%. In the relationship between the self-efficacy variable of achieving targets and chemical literacy, an R^2 of 0.371, or 37.1%, was obtained. This means that the self-efficacy aspect of achieving targets influences learning outcomes by 37.1%. Lastly, in the relationship between the self-efficacy variable of problem-solving and chemical literacy, an R^2 of 0.379, or 37.9%, was obtained. This means that the self-efficacy aspect of problem-solving influences chemical literacy by 37.9%.

The achievement of the five chemical literacy indicators during the learning process indicates that students with high chemical literacy have better self-efficacy than students with low chemical literacy. Some researchers have successfully demonstrated that self-efficacy has a positive relationship in influencing academic achievement. A study by (Schneider et al., 2022) shows a positive relationship between self-efficacy and students' academic performance. This is because good self-efficacy influences chemical literacy positively. The belief in one's ability mobilizes motivation in self-confidence, cognitive ability, and actions necessary to achieve a result.

Students with high self-efficacy will make more effort to achieve their learning goals, making them more determined in their studies. Students with low self-efficacy tend to give up when facing difficult tasks, as they believe they are incapable of completing them. This leads to low motivation and affects academic performance.

In Table 9, it can be seen that all self-efficacy aspects have a positive relationship with chemical literacy, with the aspect of coping with situations having the strongest relationship compared to the others.

Response Analysis

The student response questionnaire was given at the end of the learning process to assess the extent of students' interest and acceptance of the learning methods used to enhance chemical literacy and self-efficacy in colloidal material.

Two models were employed: problem-based learning with a scaffolding strategy for the experimental class and problem-based learning for the control class. The average student response scores for both applied learning methods can be seen in Table 10.

Table 10. Average student response scores for experimental and control classes

Class	Average Student Response Score	Criteria
Experimental	42,58	Very Good
Control	39,88	Good

Based on the average student response scores in Table 10, the experimental class has a higher response compared to the control class. The average student response score in the experimental class is 42.57, classified as very good, while in the control class, it is 39.87, categorized as good. The summarized results of student responses to learning about colloidal materials are presented in Figure 2.

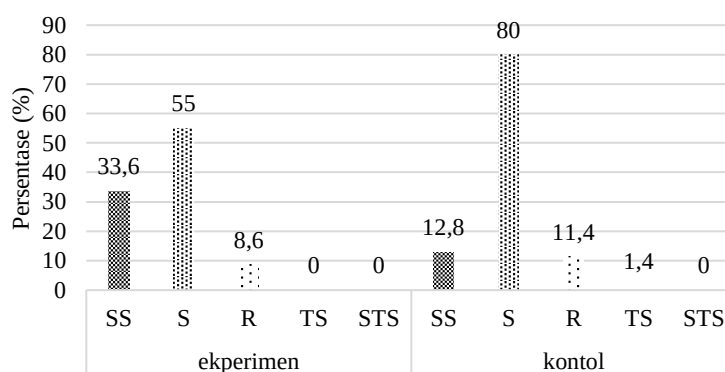


Figure 2. Student Response Results

Information:

- SS : Strongly agree
- S : Agree
- R : Uncertain
- TS : Disagree
- STS : Strongly Disagree

A significant difference is observed in the responses of the two classes to each treatment, especially in the agree responses, with a percentage of 55% in the experimental class and 80% in the control class. Students in the experimental class prefer strongly agree responses over agree responses, while students in the control class favor agree responses.

Research by Jarvis & Baloyi (2020) stated that scaffolding strategies in the learning process receive positive responses because they are engaging, easier to understand, and make teaching more efficient and interactive.

Some advantages of applying scaffolding strategies with problem-based learning in colloidal material include: (1) problem-based learning with scaffolding strategies can enhance students' self-efficacy and influence chemical literacy. (2) The application of problem-based learning with scaffolding strategies can improve students' self-efficacy and chemical literacy because they are provided with material understanding assistance. Thus, during class, students can actively engage in discussions in the process of discovery and problem-solving. (3) The learning process with problem-based learning and scaffolding strategies stimulates curiosity and a

greater sense of responsibility for their learning progress. This is evident from the chemical literacy results during the learning process.

However, there are challenges encountered in implementing problem-based learning with scaffolding strategies in colloidal materials, such as: (1) Some students are still somewhat confused in executing the syntax of problem-based learning models. Therefore, in the first meeting, the teacher must provide guidance to ensure students can complete it on time. (2) Teachers cannot monitor whether students have truly learned the given material. Although students are required to submit questions related to the material, it does not guarantee that they have learned it. There is a high likelihood that some students write these questions just before entering class by copying from their peers.

CONCLUSION

In conclusion, (1) there is a significant difference in chemical literacy in colloidal materials due to the application of scaffolding strategies in the PBL model after treatment. (2) There is a significant difference in self-efficacy in the application of scaffolding in the PBL model after treatment. (3) There is a significant positive relationship between chemical literacy and self-efficacy after treatment. The correlation between the self-efficacy variable and chemical literacy in the Pearson correlation (r_{xy}) of 0.674 indicates a strong relationship between self-efficacy and chemical literacy, with an R^2 of 0.454, meaning that self-efficacy contributes 45.4% to chemical literacy. In addition, (4) there is a more positive response to learning using scaffolding strategies with the PBL model compared to learning without scaffolding strategies in the PBL model.

REFERENCES

- Ad'hiya, E., & Laksono, E. W. (2018). Development and validation of an integrated assessment instrument to assess students' analytical thinking skills in chemical literacy. *International Journal of Instruction*, 11(4), 241–256. <https://doi.org/10.12973/iji.2018.11416a>
- Álvarez-Huerta, P., Muela, A., & Larrea, I. (2022). Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge. *Thinking Skills and Creativity*, 43(January). <https://doi.org/10.1016/j.tsc.2022.101003>
- Andersen, A. L., & Rösiö, C. (2021). Continuing Engineering Education (CEE) in Changeable and Reconfigurable Manufacturing using Problem-Based Learning (PBL). *Procedia CIRP*, 104, 1035–1040. <https://doi.org/10.1016/j.procir.2021.11.174>
- Awadelkarim, A. A. (2021). An analysis and insight into the effectiveness of scaffolding: EFL instructors'/teachers' perceptions and attitudes. *Journal of Language and Linguistic Studies*, 17(2), 828–841. <https://doi.org/10.52462/jlls.58>
- Green, J. D., & Dillard, B. (2021). Scaffolding the Scaffold: Creating Graphic Organizers to Support Your Students' Learning. *Transformative Dialogues: Teaching & Learning Journal*, 14(2), 61–74. <https://journals.psu.edu/td/article/view/1495>
- Herdiawan, H., Langitasari, I., & Solfarina, S. (2019). Penerapan PBL untuk Meningkatkan Keterampilan Berpikir Kreatif Siswa pada Konsep Koloid. *EduChemia (Jurnal Kimia Dan Pendidikan)*, 4(1), 24. <https://doi.org/10.30870/educhemia.v4i1.4867>
- Holzer, J., Korlat, S., Pelikan, E., Schober, B., Spiel, C., & Lüftenegger, M. (2023).

- The Role of Parental Self-Efficacy Regarding Parental Support for Early Adolescents' Coping, Self-Regulated Learning, Learning Self-Efficacy and Positive Emotions. *Journal of Early Adolescence*, 0(0), 1–27. <https://doi.org/10.1177/02724316231162306>
- Jarvis, M. A., & Baloyi, O. B. (2020). Scaffolding in reflective journaling: A means to develop higher order thinking skills in undergraduate learners. *International Journal of Africa Nursing Sciences*, 12(January), 100195. <https://doi.org/10.1016/j.ijans.2020.100195>
- Kolmos, A., Holgaard, J. E., & Clausen, N. R. (2020). Progression of student self-assessed learning outcomes in systemic PBL. *European Journal of Engineering Education*, 1–23. <https://doi.org/10.1080/03043797.2020.1789070>
- Liu, M., Cai, Y., Han, S., & Shao, P. (2023). Understanding Middle School Students' Self-Efficacy and Performance in a Technology-Enriched Problem-Based Learning Program: A Learning Analytics Approach. *Journal of Educational Technology Systems*, 51(4), 513–543. <https://doi.org/10.1177/00472395231174034>
- Sari, H., Al Idrus, S. W., & Rahmawati, R. (2022). Pengembangan Modul Pembelajaran Kimia Berbasis Model Problem Based Learning (PBL) pada Materi Koloid. *Chemistry Education Practice*, 5(1), 99–106. <https://doi.org/10.29303/cep.v5i1.2697>
- Sari, S., Prihastuti, I., Irwansyah, F. S., & Farida, I. (2019). Scientific learning on the concept of colloid using literacy-based chemistry magazines. *Journal of Physics: Conference Series*, 1175(1). <https://doi.org/10.1088/1742-6596/1175/1/012017>
- Schneider, B., Krajcik, J., Lavonen, J., Salmela-Aro, K., Klager, C., Bradford, L., Chen, I. C., Baker, Q., Touitou, I., Peek-Brown, D., Dezendorf, R. M., Maestrales, S., & Bartz, K. (2022). Improving Science Achievement—Is It Possible? Evaluating the Efficacy of a High School Chemistry and Physics Project-Based Learning Intervention. *Educational Researcher*, 51(2), 109–121. <https://doi.org/10.3102/0013189X211067742>
- Stephen Danczak, B., Thompson, C., & Overton, T. (2017). *Appendix 1 Danczak-Overton-Thompson Chemistry Critical Thinking Test Version 3 (DOT V3) Chemistry Critical Thinking Test. 3.*
- Taherdoost, H. (2022). What are Different Research Approaches? Comprehensive Review of Qualitative, Quantitative, and Mixed Method Research, Their Applications, Types, and Limitations. *Journal of Management Science & Engineering Research*, 5(1), 53–63. <https://doi.org/10.30564/jmser.v5i1.4538>
- Yuriza, P. E., Adisyahputra, A., & Sigit, D. V. (2018). Correlation between higher-order thinking skills and level of intelligence with scientific literacy on junior high school students. *Biosfer*, 11(1), 13–21. <https://doi.org/10.21009/biosferjpb.11-1.2>