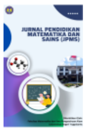

Available online at: http://journal.uny.ac.id/index.php/jpms

Jurnal Pendidikan Matematika dan Sains, 13 (1), 2025, 198–206

Fostering Confidence in Chemistry: How Problem-based Learning Elevates Self-Efficacy

Agustina Simorangkir[1]*, Eli Rohaeti[2]

[1]Chemistry Education Department, Universitas Cenderawasih, Indonesia

[2]Chemistry Education Department, Universitas Negeri Yogyakarta, Indonesia

*Correspondence Email: agustinasimorangkir@fkip.uncen.ac.id

Abstract

This article examines the role of Problem-based Learning (PBL) in fostering self-efficacy among high school students, emphasizing how this pedagogical approach enhances students' self-efficacy in their ability to understand and apply chemistry concepts. By engaging students with real-world problems, PBL promotes active participation and critical thinking, encouraging students to take ownership of their learning. The study investigates how PBL aids students in overcoming challenges traditionally associated with chemistry education by providing hands-on, direct experiences. The topic chosen in this study was chemical equilibrium which was implementated by problem based learning in experimental class. The research showed a notable difference in students' self-efficacy before and after the implementation of PBL. This article offers valuable insights for educators seeking to implement PBL in chemistry classrooms as a strategy to enhance student outcomes, foster a deeper understanding of chemistry, and cultivate sustained interest in the subject.

Keywords: *Chemical equilibrium, Chemistry learning, Problem-based learning, Self-efficacy*

How to Cite: Simorangkir, A., & Rohaeti E. (2025). Fostering confidence in chemistry: How problem-based learning elevates self-efficacy. *Jurnal Pendidikan Matematika dan Sains, 13*(1), 198–206. https://dx.doi.org/10.21831/jpms.v13i1.84437

Permalink/DOI: ***DOI:*** https://dx.doi.org/10.21831/jpms.v13i1.84437

INTRODUCTION

The fundamental obstacle in understanding chemistry does not lie in the existence of the three levels of matter representation, but rather in the fact that chemistry instruction predominantly takes place at the most abstract level, the symbolic level (Cardellini, 2012). One of the chemistry topics frequently perceived as difficult by students is chemical equilibrium. This perception is supported by the findings of Arsyad (2015), who reported that although students often regard chemical equilibrium as a challenging topic, the average level of difficulty they experience actually falls within the low category. Furthermore, Celik, Sagir, and Armagan (2009) noted that misconceptions regarding chemical equilibrium are common, largely due to the abstract nature of the concept and students' tendency to equate it with equilibrium as encountered in daily life. In line with this, Chiu, Chou, and Liu (2002) observed that chemical equilibrium is among the most difficult concepts for students to grasp across various educational levels, despite its fundamental role in both secondary and higher education chemistry curricula. Nevertheless, Ramachary and Kumar (2011) emphasized that understanding the concept of dynamic equilibrium is essential, particularly in the fields of pharmacy and medical science. The concept of dynamic equilibrium serves as a fundamental prerequisite for understanding chemical equilibrium. As a core principle in chemistry, dynamic equilibrium plays a crucial role in explaining how reactions behave over time. However, it often raises questions among students: What exactly is dynamic equilibrium? How can a system be both dynamic and in a state of balance? These questions highlight the importance of clarifying this seemingly paradoxical concept and examining whether students have truly grasped its meaning and implications (Novita, Suyono, & Yuanita, 2021).

Many students encounter significant challenges in understanding chemistry, often due to their perceptions of the subject's difficulty. According to Kausar et al. (2022), students' perceptions of chemistry content as a primary cause of their struggles were found to be particularly high. Supporting this view, Treagust et al. (2000) demonstrated that many difficulties in learning chemistry arise from the academic nature of chemistry instruction, which often lacks relevance to real-world applications. This disconnect between theory and everyday life contributes to low self-confidence and diminished self-efficacy, both of which can negatively impact motivation and academic performance.

Several studies have provided empirical evidence of this trend. For example, Uzuntiryaki and Aydın (2009) found that high school students often report low self-efficacy beliefs in chemistry, particularly when engaging with abstract topics such as chemical equilibrium and thermodynamics. Villafañe et al. (2016) observed that students with low self-efficacy in chemistry often exhibit avoidance behaviors and reduced persistence, leading to poorer academic performance. In contrast, research by Honicke et al. (2023) suggests that an increase in self-efficacy is likely to foster positive learning behaviors, ultimately enhancing student achievement.

In the field of education, fostering students' self-efficacy—their belief in their ability to succeed in specific tasks—has emerged as a key factor in improving academic achievement and motivation. In the context of chemistry, a subject often perceived as challenging, enhancing self-efficacy can lead to better learning outcomes and sustained interest in the discipline. Research identifies four primary categories of variables that contribute to the development of students' self-efficacy. Among these, students' behaviors, values, and experiences outside the formal school environment have the most significant impact on shaping their self-efficacy. Conversely, formal educational experiences and family background appear to have little direct influence, with the exception of peer learning, which is viewed as a safe and effective mode of learning within the same age group (Hinduja et al., 2024).

Bandura (1982) defined self-efficacy as an individual's capacity to control, regulate, and manage their actions, a crucial concept as it reflects one's assessment of their ability to accomplish tasks (Uzuntiryaki & Aydın, 2007). Studies show that higher levels of self-efficacy in students are positively correlated with improved academic performance (Goulão, 2014; Ramnarain & Ramaila, 2017). Understanding self-efficacy is essential for addressing critical questions about student performance, such as why students experience a decline in academic outcomes (S. Iqbal et al., 2021; Khan et al., 2020; Siddiqui et al., 2020a), lose interest in their studies (Amir-ud-Din et al., 2021), struggle with indecision regarding future academic or career goals (Zahoor & Mahmood, 2023), consider changing their specialization in higher grades (Asghar & Ajmal, 2022), or even choose to discontinue their education before pursuing higher studies (Amir-ud-Din et al., 2021). In this context, a student's self-efficacy offers valuable insights into their motivations for further education and career development.

One instructional approach that has shown promise in fostering self-efficacy is Problem-Based Learning (PBL). This student-centered pedagogy immersed learners in solving complex, real-world problems, thereby promoting critical thinking, collaboration, and active learning. The design of PBL inherently encouraged students to take ownership of their learning, which can significantly boost their confidence in understanding and applying scientific concepts (Hmelo-Silver, 2004; Siew & Mapaela, 2017). In the PBL framework, students are not only encouraged to explore problems actively, but also to collaborate with peers and seek solutions through research and experimentation, which leads to deeper learning and intrinsic motivation.

Rooted in constructivist theory, PBL posits that students achieve optimal learning outcomes when they are actively engaged in both the instructional and learning processes. By fostering meaningful learning experiences, PBL enhances students' problem-solving abilities (Raman et al., 2024). In this approach, students are presented with authentic, real-world problems and tasked with addressing them by integrating scientific theories they have studied. Particularly in chemistry education, PBL has been shown to have a transformative impact, boosting student engagement, motivation, and the development of critical thinking skills (Arsyad et al., 2024). According to Costa (2023), PBL activities are structured to span 3–4 teaching sessions and involve groups of 3–6 students, promoting collaboration whether the format is face-to-face or online. This structure not only engages students more actively in their learning journey but also enhances their motivation to learn.

PBL promotes self-efficacy by providing students with opportunities to engage with challenging problems in a supportive, collaborative environment, where success is based on effort and learning rather than rote memorization or passive absorption. A recent study by Nemakhavhani (2024) found that PBL significantly boosts student engagement by fostering collaborative learning, developing critical thinking, and enabling the practical application of knowledge. The interactive, experiential nature of PBL allows students to observe the tangible outcomes of their efforts, thus enhancing their confidence and self-efficacy in solving complex chemistry problems.

In the context of chemistry education, PBL has proven effective in improving students' understanding of difficult concepts and increasing their motivation to continue learning. Dunlap (2025) explored how students' self-efficacy, particularly in the field of software development, evolves in a PBL environment, finding that students exposed to PBL outperformed their peers taught through conventional methods. This improvement is attributed to the PBL approach's emphasis on independent problem-solving, which fosters creativity and builds confidence in addressing complex challenges (Maulidiah, 2020). Interviews with participants in PBL-based chemistry labs revealed that students exhibited enhanced self-efficacy in conducting experiments and engaging in research after the PBL experience, compared to their perceptions before the experience (Matakaa & Kowalske, 2015). Moreover, Sofiyanita & Sari (2024) suggested that PBL plays a significant role in enhancing students' self-efficacy in mastering fundamental chemistry concepts, such as Basic Chemical Laws.

This article aims to explore how PBL can be effectively implemented in chemistry classrooms to improve not only students' understanding of the subject but also their self-efficacy. By examining the impact of PBL on students' confidence and learning outcomes, this article provides insights into how educators can design learning experiences that cultivate both academic skills and psychological factors, such as self-efficacy.

METHOD

This study employed a quantitative research approach using a pre-experimental design, specifically the pre-test – post-test design. A pre-test–post-test design is a research method where participants are assessed before and after an intervention or treatment to measure the effects of the intervention. The design of the research is presented in Table 1.

Table 1. Research design

Group	Pre-test	Learning	Post-test
Experiment	O1	X1	O2

Note:
X1: Problem-based learning
O1: Self-efficacy questionnaire (pre-test)
O2: Self-efficacy questionnaire (post-test)

The research was conducted at a senior high school in Yogyakarta, involving 1 selected class, that is experimental group. In the experimental group, problem-based learning (PBL) was implemented in the classroom. The experimental activities were conducted in the chemistry laboratory. The study took place during the odd semester, with a total of 10 instructional hours allocated to the teaching and learning process. This included 2 hours for the pre-test, conducted at the start of the course, and 2 hours for the post-test, administered after the fourth session.

The selection criteria ensured that the chosen school had the academic standing, infrastructure, and curriculum alignment necessary to support the effective implementation of nstructional approaches under investigation. The population for this study comprised all grade XI students from senior high schools in Yogyakarta City, with the selected school serving as the sample. The criteria for choosing the school included an national exam score range of 70-75, an accreditation rating of A, the implementation of the K13 curriculum, and the availability of sufficient facilities, such as LCD projectors in each classroom. Additionally, The total of the studnets 32 students. The sampling method employed was purposive sampling.

The study focused on two key variables which are the independent variable and the dependent variable. According to Okoye and Hosseini (2024), independent variables are manipulated by the researcher, while dependent variables reflect the effects of those manipulations. In this study, the independent variable was the instructional approach (PBL in the experimental group, while the dependent variable was students' self-efficacy. The data collection method employed is a quantitative approach utilizing non-test techniques, with test instruments specifically designed to assess students' self-efficacy.

The instrument employed in this study was a self-efficacy questionnaire, specifically designed to evaluate students' self-efficacy in the context of problem-based learning. This questionnaire consists of 32 items, each rated on a 5-point Likert scale ranging from "strongly unsure" to "strongly confident." The development of the questionnaire was informed by a synthesis of characteristics associated with students exhibiting both high and low self-efficacy, as outlined by Eggen and Kauchak (2011), Bandura (1994), Santrock (2011), Schunk (2012), and Ormrod (2009). A comprehensive breakdown of the questionnaire items is provided in Table 2 below.

Table 2. The aspects of self-efficacy

No	Self-Efficcay Aspects	Indicators	Total Statements
1.	Beliefs	Believe you can achieve success	4
		Confident in overcoming failure and stress	3
2.	Persistence/ Perseverance	Spending a lot of time on assignments	3
3.	Effort	Uses great effort to complete tasks	4
4.	Task Orientation	Accepting a difficult task and doing it	6
5.	Performance	The learning outcomes obtained were very good	6
		Comparing performance between one student and another	4

A paired sample t-test was conducted. This test is used when a single group is evaluated at different time intervals. It compares the means of two related groups or evaluates the mean of a single group at two separate time points. When the same group is re-tested on the same measure, this t-test is referred to as a repeated measures t-test (Ross & Willson, 2017). In this study, The paired sample t-test was used to analyze the differences in cognitive learning achievement and self-efficacy of students before and after the instructional intervention in the experimental group.

RESULT AND DISCUSSION

The difference in self efficacy in the experimental class, which applied a problem-based learning model was determined by comparing pre-test and post-test scores of student self efficacy in the context of chemical equilibrium. Self-efficacy questionnaires were used as the primary research instruments. These pre-tests and post-tests served as assessments of learning progress. According to Hasanah and Muchlis (2024), implementing Assessment for Learning in chemistry education significantly enhances learning outcomes and student performance.

Pre-test were particularly valuable in this study, as they helped students identify key concepts and familiarize themselves with the types of questions that might appear later. However, as noted by Beckman (2008), the pre-tests did not make the class easier, since question formats were modified and additional questions were added. Nevertheless, the benefits of pre-testing are notable: they help clarify learning objectives and provide a benchmark for measuring learning gains (Vocational Instructional Materials Lab, 1998). In this study, student self-efficacy data were collected through questionnaires administered before and after the lessons in the experimental groups. The results, comparing the test before and after are summarized in Table 3.

Table 3. Pre-test and post-test score

Group	Test	Average
Experiment	Pre-test	92.51
	Post-test	96.82

Figure 1 illustrates the difference in pre-test and post-test self-efficacy scores between the experimental classes using problem-based learning. The figure shows a noticeable increase in self-efficacy scores following the implementation of problem-based learning. This suggests that the instructional approach had a positive impact on students' confidence in their learning abilities.

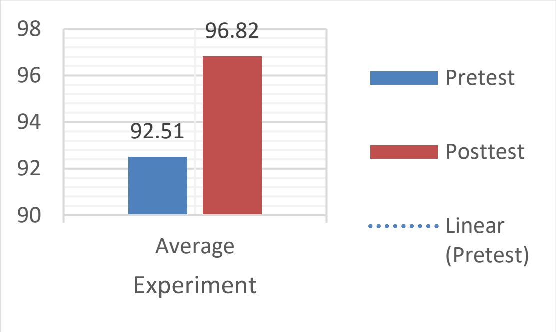

Figure 1. Pre-test and post-test of students' self-efficacy

Before conducting the hypothesis test using the paired sample t-test to assess significant differences in students' self-efficacy before and after implementing the problem-based learning model, a prerequisite test was performed to ensure that the assumptions of the test were met. These assumptions are as follows:

1. Level of Measurement: The variables must be measured at the ratio or interval level. In this study, the student self-efficacy data meet this criterion, as they are categorized as ratio and interval data.
2. Normal Distribution: The data within each group should follow a normal distribution. This assumption was tested using the Kolmogorov-Smirnov test (Afifah et al., 2023).

A paired sample t-test compared the means from two related groups to determine whether there is a statistically significant difference between them (Hasija, 2023). It is appropriate in situations where participants are measured at two points in time; in this case, before and after the instructional intervention. A summary of the normality test results, which determines the suitability of the t-test, is presented in Table 4.

Table 4. Normality test

Research Variable	**Group**	**Kolmogorov-Smirnof test**
Students' Self-Efficacy	Experiment	0.070
	Control	0.200

The normality test results for students' self-efficacy showed a significance value greater than 0.05, This suggested that students' self- follow a normal distribution. Homogenity test is seen from the results of the Levene test shown in Table 5. Levene's test is a robust and effective method for assessing the homogeneity of variances, particularly in the presence of non-normality, and has become widely used for this purpose (Gastwirth *et al*, 2010).

Table 5. Levene statistic

Research Variable	**Levene Statistic**
	Sig
Students' Self-Efficacy	0.826

Based on Table 6, students' self-efficacy scores yielded significance values greater than 0.05, indicating that the assumption of homogeneity of variance was met. Since this result aligns with the earlier finding that the data were normally distributed, both assumptions required for parametric testing were satisfied. Therefore, hypothesis testing proceeded using a Paired Sample t-test to assess the difference in students' self-efficacy before and after the implementation of problem-based learning models.

The student self-efficacy questionnaire was administered prior to and following the intervention to assess changes in students' confidence related to their learning. The collected pre-test and post-test data were analyzed using a paired sample t-test to determine whether any statistically significant differences existed between the two time points. A summary of these test results is presented in Table 6, offering insight into the potential impact of the intervention on student self-efficacy.

Research by Hu et al. (2022) supported the importance of using reliable tools to measure self-efficacy in educational research. Their validated science self-efficacy instrument, developed using the Rasch model, identified four distinct levels of self-efficacy and demonstrated measurable improvement over time. This supports the findings of the present study, suggesting that carefully designed instructional strategies can positively influence students' science self-efficacy. Furthermore, Axboe et al. (2016) highlighted the value of self-assessment tools in evaluating competencies, reinforcing the use of self-efficacy questionnaires as effective instruments for measuring educational outcomes.

Table 6. The result of paired sample t-test

Experiment Group	Paired sample t-test		
	t	df	Sig. (2-tailed)
Pre-test-Post-test	-2.375	32	0.024

The Sig. (2-tailed) value of 0.024 indicates a significant difference in students' self-efficacy before and after the implementation of the problem-based learning model. This value is below the commonly accepted threshold of 0.05, suggesting that the observed change is statistically meaningful. Therefore, the results confirm a significant improvement in self-efficacy following the intervention.

The student self-efficacy questionnaire, consisting of 32 statements, was administered as both a pre-test and post-test instrument. The paired sample t-test was used to analyze these responses, revealing an increase in average scores from pre-test to post-test, further substantiating the positive impact of problem-based learning on student self-efficacy. These findings align with previous research. Mataka and Grunert (2015) similarly observed an improvement in student self-efficacy following the application of problem-based learning. Syarafina, Jailani, and Winarni (2014) also found consistent gains across two learning cycles, with average scores increasing from 84.4 in the first cycle to 97.03 in the second.

The underlying mechanism of this improvement lies in the structure of problem-based learning (PBL) itself. By promoting discovery-driven, student-centered problem solving, PBL helps learners develop essential skills to systematically approach and solve complex tasks. Dunlap (2005) reported significant gains in self-efficacy resulting from this reflective, challenge-based process, a view supported by Hmelo-Silver (2004), who emphasized learning through active engagement and reflection. Additionally, Mataka and Kowalske (2015) found that PBL encourages greater responsibility during laboratory practicum sessions, while Rokhmawati, Djatmika, and Wardana (2012) noted increased student confidence and self-efficacy between successive learning cycles. These findings collectively reinforce the conclusion that PBL is a highly effective instructional strategy for enhancing student self-efficacy.

Building on this evidence, problem-based learning demonstrated a significantly greater impact on student self-efficacy when compared to more traditional instructional models. The key difference lies in the instructional syntax: PBL begins with the presentation of real-world problems, immediately engaging students in active problem solving (Arends, 2008; Eggen & Kauchak, 2012).

CONCLUSION

In conclusion, this article highlights the transformative impact of Problem-Based Learning (PBL) on enhancing students' self-efficacy in the field of chemistry. By engaging students in real-world problems and encouraging independent problem-solving, PBL fosters a deeper understanding of chemistry concepts while simultaneously boosting students' confidence in their abilities. The findings suggest that PBL not only improves students' practical skills in conducting experiments but also cultivates a greater sense of self-belief, empowering them to approach complex tasks with increased competence. As a result, PBL proves to be a powerful pedagogical approach for nurturing both academic growth and the development of essential skills required for future success in chemistry and beyond**.**

DAFTAR PUSTAKA

Afifah, S., Mudzakir, A., & Nandiyanto, A. B. D. (2023). How to calculate paired sample t-test using spss software: from step-by-step processing for users to the practical examples in the analysis of the effect of application anti-fire bamboo teaching materials on student learning outcomes. *Indonesian Journal of Teaching in Science*, *2*(1),81-92. https://doi.org/10.17509/ijotis. v2il.45895

Amiruddin, R., Mahmood H. Z., Abbas F., Salman V., & Zafar S. (2021). Leaving studies because of lack of interest: An analysis of the risk factors of school dropouts in Pakistan. *Quality & Quantity*, *56*, 1–26. https://doi.org/10.1007/s11135-02101266-9

Arsyad, M. (2015). What’s the main difficulty of chemical-equilibrium topic?. *Proceedings of the International Seminar on Mathematics, Science, and Computer Science Education*, 2-31.

Arsyad, M., Guna, S., & Barus. (2024). Enhancing chemistry education through problem-based learning: analyzing student engagement, motivation, and critical thinking. *International Journal of Curriculum Development Teaching and Learning Innovation*, 2, 110-117

Asghar S., & Ajmal M. A. (2022). Adolescents' career decision making: A qualitative study. *Pakistan Journal of Humanities and Social Sciences*, *10*(3), 952–967. https://doi.org/10.52131/pjhss.2022.1003.0259

Axboe, M.K., Christensen, K.S., & Kofoed, P.E. Ammentorp, J. (2016). Development and validation of a self-efficacy questionnaire (SE-12) measuring the clinical communication skills of health care professionals. *BMC Med Educ*, *16*, 1-10. https://doi.org/10.1186/s12909-016-0798-7

Aydin, Y. C., & Uzuntiryaki, E. (2009). Development and psychometric evaluation of the high school chemistry self-efficacy scale. *Educational and Psychological Measurement*, *69*, 868-880. https://doi.org/10.1177/0013164409332213

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, *37*(2), 122-147. http://10.1037/0003-066X.37.2.122

Bandura, A. (1994). Self-efficacy. London: Wiley Online Library.

Beckman, W. S. (2008). Pre-testing as a method of conveying learning objectives. *Journal of Aviation/Aerospace Education & Research*, *17*(2), 60-70. https://doi.org/10.15394/jaaer.2008.1447

Cardellini, Liberato. (2012). Chemistry: why the subject is difficult?. *Educación Química*, *23*(2), 305-310. http://doi.10.1016/S0187-893X(17)30158-1

Costa, A. M., Escaja, N., Fité, C., González, M., Madurga, S., & Fuguet, E. (2023). Problem-based learning in graduate and undergraduate chemistry courses: face-to-face and online experiences**.** *Journal of Chemical Education*, *100* (2), 597-606**.** https://doi.10.1021/acs.jchemed.2c00741

Eggen, P. D., & Kauchak, D. P. (2012). Strategies and models for teacher sixth Edition. Boston: Pearson.

Gastwirth, J.L., & Gel, Y.R., & Miao, W. (2010). The impact of levene's test of equality of variances on statistical theory and practice. *Statistical Science*, *24*(3), 343–360. https://doi.org/10.1214/09-STS301

Goulão, M. d. F. (2018). The relationship between self-efficacy and academic achievement in adults' learners. *Athens Journal of Education*, *1*(3), 237-246. Doi: https://doi.org/10.30958/aje.1-3-4

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hasija, Y. (2023). All About Bioinformatics *from Beginner to Expert*. Academic Press. https://doi.org/10.1016/C2022-0-01349-0

Hinduja, P., Fakir Mohammad, R., & Siddiqui, S. (2024). Factors influencing students' academic self-efficacy in related domains. *SAGE Open*, *14*(4), 1-24. https://doi.org/10.1177/21582440241289738

Honicke, T., Broadbent, J., & Fuller-Tyszkiewicz, M. (2023). The self-efficacy and academic performance reciprocal relationship: the influence of task difficulty and baseline achievement on learner trajectory. *Higher Education Research & Development*, *42*(8), 1936–1953. https://doi.org/10.1080/07294360.2023.2197194

Hu, X., Jiang, Y., & Bi, H. (2022). Measuring science self-efficacy with a focus on the perceived competence dimension: using mixed methods to develop an instrument and explore changes through cross-sectional and longitudinal analyses in high school. *International Journal of STEM Education*, *9*(47), 1-24. https://doi.org/10.1186/s40594-02200363-x

Hasanah, S. A., & Muchlis, M. (2024). The effect of assessment for learning in chemistry learning on students' learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 5992–6000. https://doi.org/10.29303/jppipav10i8.7611

Iqbal S., Aslam R., & Niazi S. (2021). Critical analysis of the academic |performance of students at high secondary level (HSL). *Pakistan Social Sciences Review*, *5*(4), 547–557. https://doi.org/10.35484/pssr.2021(5-IV)42

Kausar, F. N., Ghazala, N., & Haroon, A. (2022). Causes of students' learning difficulties in secondary school chemistry: a study in context of content and assessment strategies. *Journal of Positive School Psychology*, *6*(10), 4443-4463

Khan, M. A., Asif, M., Khan, A. S., & Azeem, M. (2020). Factors affecting the academic performance of students at higher secondary school level in Malakand District. *Pakistan Journal of Society, Education and Language (PJSL)*, *6*(2), 197–207.

Maulidia, F., Saminan., & Abidin, Z. (2020). The implementation of problem-based learning (PBL) model to improve creativity and self- efficacy of field dependent and field independent students. *Malikussaleh Journal of Mathematics Learning (MJML)*, *3*(1, 13-17. https://doi.org/10.29103/mjml.v3il.2402

Matakaa, L. M., & Kowalske, M. G. (2015). The influence of PBL on students‘ self-efficacy beliefs in chemistry. *Chemistry Education Research and Practice*, *16*(4), 929-938. https://doi.org/10.1039/c5rp00099h.

Nemakhavhani, R.B. (2024). Enhancing student engagement through problem-based learning: a case of the built environment. *International Conference on Education Research*. *1*(1). 238-245. https://doi.org/10.34190/icer.1.1.3053.

Novita, D., Suyono, S., & Yuanita, L. (2021). Dynamic equilibrium: The conception of a prospective chemistry teacher. *Proceedings of the International Joint Conference on Science and Engineering (IJCSE 2021), Advances in Engineering Research*, 209. 179-184.

Okoye, K., & Hosseini, S. (2024). Understanding dependent and independent variables in research experiments and hypothesis testing. in: r programming. Springer, Singapore. 99-107. https://doi.org/10.1007/978-981-97-3385-9_5

Ormrod, J. E. (2009). Educational psychology. New Jersey, NJ: Pearson Merrill Prentice Hall.

Raman, Y., Surif, J., & Ibrahim, N. H. (2024). The effect of problem based learning approach in enhancing problem solving skills in chemistry education: a systematic review. *International Journal of Interactive Mobile Technologies (iJIM), 18(5)*,91-111. https://doi.org/10.3991/ijim.v18i05.47929

Ramnarain, U., & Ramaila, S. (2018). The relationship between chemistry selfefficacy of South African first year university students and their academic 90 performance. *Chemistry Education Research and Practice*, *19*, 60-67. https://doi.org/10.1039/c7rp00110j

Ross, A., & Willson, V.L. (2017). Paired samples t-test. in: basic and advanced statistical tests. Sense Publishers, Rotterdam. https://doi.org/10.1007/978-94-6351-086-8_4

Sofiyanita1., & Sari, E. K. (2024). The effect of the problem-based learning (pbl) model on student self-efficacy in basic chemical laws. *International Conference on Emerging Trends on Science Education*, *1*, 176-184.

Schunk, D.H. (2012). Teori-teori pembelajaran: perspektif pendidikan (Ed 6). Yogyakarta: Pustaka Pelajar.

Siddiqui S., Soomro N. N., & Thomas M. (2020). Blended learning source of satisfaction of psychological needs: An empirical study conducted on O-levels chemistry students in metropolis city of Pakistan. *Asian Association of Open Universities Journal*, *15*(1), 49–57. https://doi.org/10.1108/AAOUJ-11-2019-0054

Treagust, D., Duit, R., & Nieswandt, M. (2000). Sources of students difficulties in learning Chemistry. *Educación Química*, *11*. 228-235. https://doi.org/10.22201/fq.18708404e.2000.2.66458.

Uzuntiryaki, E., & Aydın, Y. C.(2007). Development and psychometric evaluation of the high school chemistry self-efficacy scale. *Sage Publication*, *69*(5), 868–880. https://doi.org/10.1177/0013164409332213

Vocational Instructional Materials Lab. (1998). Applied Mathematics: Targets for Learning Strategies for Preparing Successful Problem Solvers in the Workplace. *Columbus: Ohio State University*, 36-40.

Witoko, R. & Wardono. (2019). Analisis model pembelajaran open-ended learning (oel) dengan assessment for learning (afl) ditinjau dari kreativitas belajar matematika. *PRISMA: Prosidinng Seminar Nasional Matematika*, *2*, 748–753.

Zahoor I., & Mahmood M. (2023). Career maturity level of intermediate students: A comparative analysis. *Pakistan Journal of Educational Research*, *6*(1), 49-60. https://doi.org/10.52337/pjer.v6i1.717

BIOGRAPHIES OF AUTHORS

Agustina Simorangkir, **M.Pd.** is a lecturer in Chemistry Education at Universitas Cenderawasih. She teaches courses including General and Inorganic Chemistry, Innorganic and Organic Chemistry Practicums, and Coordination Chemistry. Her research focuses on problem-based learning, self-efficacy, and chemical equilibrium. Contact: agustinasimorangkir@fkip.uncen.ac.id.

Prof. Dr. Eli Rohaeti, M.Si. is a professor in Chemistry Education at Yogyakarta State University. She teaches courses such as Molecular Dynamics, Polymer Chemistry, and Research Methods. Her research interests include physical chemistry, chemical equilibrium, polymers and surface chemistry, colloids, chemical literacy, critical thinking, and educational research. Contact: eli_rohaeti@uny.ac.id.