JPPIPA 8(5) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effect of Project-Based Learning on Pre-Service Chemistry Teachers' Self-Efficacy and Critical Thinking Skills

Dwi Wahyudiati[1*], Devi Qurniati[1]

[1]Chemistry Education Department, Universitas Islam Negeri Mataram, Mataram, Indonesia

Received: June 29, 2022
Revised: November 11, 2022
Accepted: November 23, 2022
Published: November 30, 2022

Corresponding Author:
Dwi Wahyudiati
dwiwahyudiati@uinmataram.ac.id

DOI: 10.29303/jppipa.v8i5.1834

Abstract: The current research aims to: 1) determine the difference between self-efficacy (SE) and critical thinking skills (CTS) of pre-service chemistry teachers who were taught using the PjBL model; and 2) know how much the implementation of the PjBL model influences their self-efficacy (SE) and critical thinking skills (CTS). This experimental research was conducted through a quasi-experimental nonequivalent pretest-posttest control group design. The Cronbach's alpha coefficient value test for the validation of the instruments resulted in SE α = .86 and CTS α = .85. Manova test with a significance level of .05 was also performed to analyze the data. The results indicated: 1) there were significant differences in self-efficacy (SE) and critical thinking skills (CTS) before and after the implementation of the PjBL model, and 2) there was a significant effect of implementing the PjBL model on self-efficacy (SE) and critical thinking skills (CTS) with the contribution of the PjBL model of 35%. These results contribute to educational literature as an alternative solution for lecturers to apply the PjBL model in chemistry education learning in universities. Considering the characteristics of the learning material, students, and environmental conditions will maximize teamwork cooperation by using project-based activities to develop students' 21st-century skills.

Keywords: PjBL model; self-efficacy; critical thinking skills; pre-service teachers; chemistry education

Introduction

Learning purpose in higher education denotes to focus on achieving 21st-century skills. Especially pre-service chemistry teachers, they have to be able to compete in the era of the industrial revolution 4.0 since it requires 21st-century skills, including collaboration and communication, critical thinking, creative thinking, problem-solving, and self-efficacy (Patonah et al., 2021; Sumardi et al., 2020). However, the chemistry learning objectives focus more on understanding concepts than soft skills development. It leads to pre-service chemistry teachers' low self-efficacy and critical thinking skills (Irwanto et al., 2021; Wahyudiati, 2022). Thus, the chemistry education learning system must be reformed by signifying soft skills such as self-efficacy and critical thinking skills by applying innovative and collaborative project-based learning models.

Self-efficacy is an individual's belief in their ability to perform a task (Villafañe et al., 2014). Self-efficacy has a relationship with critical thinking skills. Critical thinking skills are the ability to analyze, formulate hypotheses, and alternate problem solving to prove hypotheses (Oon Seng, 2009; Patonah et al., 2021; Wahyudiati, 2022). In addition, pre-service chemistry teachers' critical thinking skills and self-efficacy are necessary because it relates to the skills of applying fact-based knowledge and context as an effort to train problem-solving skills and develop careers in the Industrial Revolution 4.0 era (Tosun & Taskesenligil, 2013; Wahyudiati, Sutrisno, & Louise, 2019a). However, studies that focus on self-efficacy (SE) and critical thinking skills (CTS) among pre-service chemistry teachers are still limited and focus more on cognitive learning outcomes (Xu et al., 2013). For this reason, further research is required to measure the self-efficacy (SE) and critical thinking skills (CTS) of pre-service teachers of chemistry so that the learning objectives can be achieved optimally.

How to Cite:
Wahyudiati, D., & Qurniati, D. (2022). The Effect of Project-Based Learning on Pre-Service Chemistry Teachers' Self-Efficacy and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2307–2311. https://doi.org/10.29303/jppipa.v8i5.1834

Critical-thinking skills (CTS) is one of the chemistry learning objectives that must be acquired at the university level. The ability to think critically as a 21st-century skill is crucial for pre-service chemistry teachers to generate competent graduates in their field to survive in the job market competition (Fadli & Irwanto, 2020; Sumardi et al., 2020; Sutrisno et al., 2020). The development of critical thinking skills through classroom learning activities and experimental activities in the laboratory is believed could increase curiosity, self-efficacy, responsibility, and collaboration & communication skills which are the main provisions for each individual to survive in a global society (Osborne et al., 2003; Syafrial et al., 2022). Moreover, SE and CTS skills cannot only be taught using textbooks or lecturing. Still, they must be stimulated through real activities relevant to everyday life to improve the ability to investigate, analyze, observe, express opinions, respond to the views of others, and dare to make decisions.

Pre-service chemistry teachers' self-efficacy and critical thinking skills development can be accomplished through applying a project-based learning model (PjBL). The advantages of the PjBL are it trains students' abilities to identify and formulate problems, identify research variables, develop and prove hypotheses, and report experimental results (Syafrial et al., 2022; Wahyudiati, 2021a, 2021b). Likewise, project-based or experimental activities could develop students' self-efficacy, critical thinking, and problem-solving skills. In addition, experimental learning, such as proving the chemistry concept, is needed to build self-efficacy and critical thinking skills (Irwanto et al., 2021). Therefore, through the constructivist-based PjBL model implementation, it is hoped that it would increase pre-service teachers' self-efficacy, critical thinking, and problem-solving skills. The focus of this study was to determine the difference between self-efficacy (SE) and critical thinking skills (CTS) for pre-service chemistry teachers who were taught using the PjBL model and traditional teaching. In addition, this research benefits lecturers and researchers in practising project-based learning models to improve the 21st-century skills of pre-service chemistry teachers.

Method

Research Design

This experimental research was conducted with a quasi-experimental nonequivalent pretest-posttest control group design (Table 1). The pretest-posttest design was used to compare the group that was given treatment (experimental class) with the group that was not given treatment or the control class (De Vet et al., 2017). This research consisted of one independent variable (PjBL model) and two independent variables, namely self-efficacy (SE) and critical thinking skills (CTS). The population sample was 40 pre-service teachers of chemistry at the Mataram State Islamic University. The experimental and control classes were determined randomly using the cluster random sampling technique.

Table 1. Nonequivalent pretest and posttest control group design

Group	Pretest	Treatment	Posttest
Experimental	X_1, Y_1	PjBL model	X_2, Y_2
Control	X_1, Y_1	Discussion model	X_2, Y_2

Description:

X_1 = Self Eficacy (before treatment)
X_2 = Self Eficacy (after treatment)
Y_1 = Critical Thinking Skills (before treatment)
Y_2 = Critical Thinking Skills (after treatment)

Data Collection Instrument and Data Analysis

The data collection instrument on critical thinking skills employed six indicators (Facione, 2011), namely: (1) interpretation, (2) inference, (3) analysis, (4) explanation, (5) evaluation, and (6) self-regulation. Meanwhile, the instrument for collecting the self-efficacy data consisted of 5 indicators (Bandura, 2006): (1) individuals are confident in their abilities to overcome task difficulties, (2) individuals have confidence in facing difficulties in finding references or library sources, (3) individuals are diligent in completing assignments; (4) individuals can face obstacles in achieving goals, and (e) individuals can use life experiences as a step to gain success. Both instruments had been validated. Based on the results of the empirical validation test, the Cronbach alpha coefficient value of the SE instrument was α= .86, and the CTS was α= .85, which means that the Cronbach alpha value of the test was above the acceptance limit of α=.70 so that both instruments were declared reliable (Creswell & Creswell, 2017). Data analysis was performed using the Manova test with a significance level of α=.05. The Manova test was conducted to determine the difference between SE and CTS taught using the PjBL and discussion models. The Manova test was also done to assess the effect of implementing the PjBL model on SE and CTS and how much the PjBL model contributes to pre-service teachers of chemistry's SE and CTS.

Result and Discussion

Manova test was completed to determine the significance difference between pre-service chemistry teachers' SE and CTS between the experimental and control classes. Based on the results, it obtained a significance value of 0.000 < (0.05), which means that there were differences in pre-service chemistry teachers' SE and CTS simultaneously before and after the PjBL model implementation (Table 2).

Table 2. Manova Test results simultaneously before and after PjBL model implementation

Effect	F	Hypothesis df	Error df	sig
SE & CTS	184.804	7.000	198.000	0.000

The contribution test of the PjBL model before and after the treatment of SE and CTS simultaneously was meant to measure the effect of the independent variable on the dependent variable, which was determined based on the *partial eta squared* value. Based on the study's results, the *partial eta squared* value was 0.350 with a significance value of 0.000 α < (0.05), as shown in Table 3. It means that there was a contribution of the PjBL model before and after the treatment of SE and student CTS simultaneously, with the percentage of the contribution of the PjBL model simultaneously was 35%.

Table 3. Contribution of PjBL Model between before and after treatment of SE and CTS simultaneously

Effect	F	Error df	Sig	Partial eta squared
Hotelling's Trace	49.712	89.000	0.000	0.350

The first research objective was to uncover the difference between the self-efficacy (SE) and critical thinking skills (CTS) of pre-service chemistry teachers who were taught using the PjBL and discussion models. The results of the Manova test showed a significant difference in self-efficacy (SE) and critical thinking skills (CTS) of pre-service chemistry teachers through the application of the PjBL model. This significant influence is caused by the learning stages of the PjBL model provide opportunities for participants to be actively involved in formulating problems, compiling, designing, and evaluating project activities or experimental activities to solve problems to make learning more meaningful (Patonah et al., 2021; Tan, 2009; Wahyudiati et al., 2020; Yustina et al., 2022). Significant learning will be realized if students are allowed to be active and independent in constructing knowledge and attitudes during the learning process. Moreover, the learning experiences are based on life experience in solving problems so they can enhance curiosity, responsibility, independent learning, and analytical and synthetic abilities. These will positively impact pre-service chemistry teachers' self-efficacy and critical thinking skills (Zeidan & Jayosi, 2014; Zhou, 2022). Another advantage of the PjBL model is that it is a learning model based on pe Vygotsky's social constructivist learning approach.

Vygotsky's social constructivist learning approach implementation is relevant to the syntactic advantages of the PjBL model, which emphasizes social interaction between students, students and lecturers, or students and the environment. In contrast to the control class with teacher-centred learning, students are not actively involved in constructing knowledge and skills during the learning process. These create barriers to students' self-efficacy and critical thinking skills (Tosun & Taskesenligil, 2013; Villafañe et al., 2014; Wahyudiati, 2021b, 2022). The findings also agree with the statement that a teacher-centred learning practice tends to ignore the concept of constructivist learning, which makes learning less significant and negatively affects the pre-service teachers' self-efficacy and critical thinking skills (Turkoguz, 2012; Turpin & Cage, 2004; Verawati et al., 2021; Villafañe & Lewis, 2016; Wahyudiati, Sutrisno, & Louise, 2019b). Therefore, the application of the PjBL model is more effective in developing pre-service teachers' self-efficacy and critical thinking skills compared to the model applied to the control class.

The application of the PjBL model not only significantly impacts pre-service chemistry teachers' self-efficacy (SE) and critical thinking skills (CTS) but also contributes quite highly to their SE and CTS improvement with a percentage of 35%. The significant contribution is due to the project-based and collaborative nature of the PjBL model. In addition, the PjBL benefit is that the learning activities train students to formulate problems, identify research variables, formulate hypotheses and prove hypotheses, and collaborate to report and communicate experimental results (Turkoguz, 2012; Turpin & Cage, 2004; Verawati et al., 2021; Villafañe & Lewis, 2016; Yusuf & Adeoye, 2012; Yusuf, 2011; Zhou, 2022). These findings are similar to previous research, which proved that inquiry-based learning or problem-solving activities are very effective in increasing curiosity, self-confidence, and problem-solving skills that individuals need in dealing with problems in everyday life (Sutrisno et al., 2020; Syafrial et al., 2022; Wahyudiati, 2022). In addition, students with SE and CTS will be ready to face challenges in the job market to compete in the era of globalization and solve problems in family and community life (Yusuf, 2011; Zhou, 2022).

Another advantage of the PJBL model is the inquiry-based PjBL to develop pre-service chemistry teachers' critical thinking and self-efficacy. Inquiry and project-based learning approaches build their critical thinking and problem-solving skills (Irwanto et al., 2021; Miller et al., 2018; Tan, 2009; Fadli & Irwanto, 2020). Not only effective in developing student problem-solving skills, but PjBL is also helpful in developing student self-efficacy (Teo et al., 2014; Wahyudiati, 2021b, 2022). The current research showed that applying the PjBL model in chemistry learning in universities can increase pre-service chemistry teachers' SE and CTS. Therefore, the researcher recommends further research to investigate the effect of the PjBL model on cognitive learning outcomes and other 21st-century skills such as communication and collaboration skills, problem-solving skills, and creative thinking skills to obtain more complete research results.

Conclusion

Based on the research findings, it can be summarized there were significant differences in self-efficacy (SE) and critical thinking skills (CTS) before and after the implementation of the PjBL model and there was a significant effect of implementing the PjBL model on self-efficacy (SE) and critical thinking skills (CTS) with the contribution of the PjBL model of 35%. Based on the research findings, it can be used as an alternative solution for lecturers to apply the PjBL model in chemistry learning in universities. The characteristics of the material, the students, and environmental conditions need to be considered to maximize teamwork in implementing project-based activities to develop pre-service chemistry teachers' 21st-century skills.

References

Bandura, A. (2006). Guide to the construction of self-efficacy scales. *Self-Efficacy Beliefs of Adolescents,* 307–337.

Creswell, J. W., & Creswell, J. D. (2017). R*esearch design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

De Vet, H. C. W., Mokkink, L. B., Mosmuller, D. G., & Terwee, C. B. (2017). Spearman–Brown prophecy formula and Cronbach's alpha: different faces of reliability and opportunities for new applications. Journal of Clinical Epidemiology, 85, 45–49. https://doi.org/10.1016/j.jclinepi.2017.01.013

Facione, P. A. (2011). Critical Thinking : What It Is and Why It Counts.

Fadli, A., & Irwanto. (2020). The effect of local wisdom-based ELSII learning model on the problem solving and communication skills of pre-service islamic teachers. International Journal of Instruction, 13(1), 731–746. https://doi.org/10.29333/iji.2020.13147a

Irwanto Irwanto, Eli Rohaeti, & A.K. Prodjosantoso. (2021). A Survey Analysis of Pre-service Chemistry Teachers' Critical Thinking Skills. MIER Journal of Educational Studies Trends & Practices, 8(1), 57–73. https://doi.org/10.52634/mier/2018/v8/i1/1423

Miller, Friedmann, J., Childs, A., & Hillier, J. (2018). Approaching gender equity in academic chemistry: lessons learned from successful female chemists in the UK. Chemistry Education Research and Practice, 19(1), 24–41. https://doi.org/10.1039/C6RP00252H

Oon Seng, T. (2009). Problem Based Learning And Creativity. Problem-Based Learning: The Future Frontiers, 17–30. Retrieved from http://www.tp.edu.sg/pbl._tan_oon_seng.pdf

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. International Journal of Science Education, 25(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Patonah, S., Sajidan, Cari, & Rahardjo, S. B. (2021). The effectiveness of STLC (science technology learning cycle) to empowering critical thinking skills. International Journal of Instruction, 14(3), 39–58. https://doi.org/10.29333/iji.2021.1433a

Sumardi, L., Rohman, A., & Wahyudiati, D. (2020). Does the teaching and learning process in primary schools correspond to the characteristics of the 21st century learning? International Journal of Instruction, 13(3), 357–370. https://doi.org/10.29333/iji.2020.13325a

Sutrisno, H., Wahyudiati, D., & Louise, I. S. Y. (2020). Ethnochemistry in the Chemistry Curriculum in Higher Education: Exploring Chemistry Learning Resources in Sasak Local Wisdom. Universal Journal of Educational Research, 8(12A), 7833–7842. https://doi.org/10.13189/ujer.2020.082572

Syafrial, Ashadi, Saputro, S., & Sarwanto. (2022). Trend creative thinking perception of students in learning natural science: Gender and domicile perspective. International Journal of Instruction, 15(1), 701–716. https://doi.org/10.29333/iji.2022.15140a

Tan, O. (2009). Problem-Based Learning and Education. In Learning.

Teo, T. W., Goh, M. T., & Yeo, L. W. (2014). Chemistry education research trends: 2004-2013. Chemistry Education Research and Practice, 15(4), 470–487. https://doi.org/10.1039/c4rp00104d

Tosun, C., & Taskesenligil, Y. (2013). The effect of problem-based learning on undergraduate students' learning about solutions and their physical properties and scientific processing skills. Chemistry Education Research and Practice, 14(1), 36–50. https://doi.org/10.1039/c2rp20060k

Turkoguz, S. (2012). Learn to teach chemistry using visual media tools. Chemistry Education Research and Practice, 13(4), 401–409. https://doi.org/10.1039/c2rp20046e

Turpin, T., & Cage, B. N. (2004). Effect of an integrated, activity-based science curriculum on student achievement, science process skills, and science attitudes. Electronic Journal of Literacy Through Science, 3(1), 1–17. Retrieved from https://www.csun.edu/science/ref/curriculum/reforms/nses/nses-complete.pdf

Verawati, N. N. S. P., Hikmawati, H., Prayogi, S., & Bilad, M. R. (2021). Reflective Practices in Inquiry Learning: Its Effectiveness in Training Pre-Service Teachers' Critical Thinking Viewed from Cognitive

Styles. Jurnal Pendidikan IPA Indonesia, 10(4), 505–514. https://doi.org/10.15294/jpii.v10i4.31814

Villafañe, S. M., Garcia, C. A., & Lewis, J. E. (2014). Exploring diverse students' trends in chemistry self-efficacy throughout a semester of college-level preparatory chemistry. Chemistry Education Research and Practice, 15(2), 114–127. https://doi.org/10.1039/c3rp00141e

Villafañe, S. M., & Lewis, J. E. (2016). Exploring a measure of science attitude for different groups of students enrolled in introductory college chemistry. Chemistry Education Research and Practice, 17(4), 731–742. https://doi.org/10.1039/c5rp00185d

Wahyudiati, D. (2021a). Ethnochemistry : Material Relevance Analysis of The Periodic System of Elements With Sasak Local Wisdom. SPIN Jurnal Kimia & Pendidikan Kimia, 3(2), 190–199. https://doi.org/10.20414/spin.v3i2.4402

Wahyudiati, D. (2021b). Investigating Problem Solving Skills and Chemistry Learning Experiences of Higher Education Base on Gender and Grade Level Differences. Journal of Science and Science Education, 2(2), 62–67. https://doi.org/10.29303/jossed.v2i2.632

Wahyudiati, D. (2022). Critical Thinking Skills and Scientific Attitudes of Pre-Service Chemistry Teachers Through the Implementation of Problem-Based Learning Model. Jurnal Penelitian Pendidikan IPA, 8(1), 216–221. https://doi.org/10.29303/jppipa.v8i1.1278

Wahyudiati, D., Rohaeti, E., Irwanto, Wiyarsi, A., & Sumardi, L. (2020). Attitudes toward chemistry, self-efficacy, and learning experiences of pre-service chemistry teachers: Grade level and gender differences. International Journal of Instruction, 13(1), 235–254. https://doi.org/10.29333/iji.2020.13116a

Wahyudiati, D., Sutrisno, H., & Louise, I. S. Y. (2019a). Investigation of attitudes toward chemistry and learning experiences of pre-service chemistry teachers. MIER Journal of Educational Studies, Trends and Practices, 9(2). DOI: 10.52634/mier/2019/v9/i2/1384

Wahyudiati, D., Sutrisno, H., & Supiah, I. (2019b). Self-Efficacy And Attitudes Toward Chemistry Of Pre-Service Chemistry Teachers: Gender And Grades Level Perspective. International Journal of Scientific & Technology Research, 8(09). Retrieved from www.ijstr.org

Xu, X., Villafane, S. M., & Lewis, J. E. (2013). College students' attitudes toward chemistry, conceptual knowledge and achievement: Structural equation model analysis. Chemistry Education Research and Practice, 14(2), 188–200. https://doi.org/10.1039/c3rp20170h

Yustina, Imam, M., Ariska, D., Arnentis, & Darmadi. (2022). The Effect of E-Learning Based on the Problem-Based Learning Model on Students ' Creative Thinking Skills During the Covid-19 Pandemic. International Journal of Instruction, 15(2), 329–348. Retrieved from https://www.e-iji.net/dosyalar/iji_2022_2_19.pdf

Yusuf, F., & Adeoye, E. (2012). Developing Critical Thinking and Communication Skills in Students: Implications for Practice in Education. African Research Review, 6(1), 311–324. https://doi.org/10.4314/afrrev.v6i1.26

Yusuf, M. (2011). The impact of self-efficacy, achievement motivation, and self-regulated learning strategies on students' academic achievement. Procedia - Social and Behavioral Sciences, 15, 2623–2626. https://doi.org/10.1016/j.sbspro.2011.04.158

Zeidan, A. H., & Jayosi, M. R. (2014). Science Process Skills and Attitudes toward Science among Palestinian Secondary School Students. World Journal of Education, 5(1), 13–24. https://doi.org/10.5430/wje.v5n1p13

Zhou, X. (2022). Research on the Relationship between Self-efficacy and Inquiry Community Model. International Journla of Emerging Technologies in Learning. Doi: 17(01), 191–205. 10.3991/ijet.v17i01.28547