JIPTEK: Jurnal Ilmiah Pendidikan Teknik dan Kejuruan
Jurnal Homepage: https://jurnal.uns.ac.id/jptk

Comparison of the Effectiveness of Blended Project-Based Learning and Project-Based Learning Strategies on Chemistry Concept Understanding

Wilyati Agustina Bangun[1*], Alfiati Hasanah[2], Ririn Ningkeula[3]
[1]Program Studi Pendidikan Biologi, Fakultas Eksakta dan Keolahragaan, Universitas Insan Budi Utomo, Indonesia
[2,3]Program Studi Teknik Mesin, Fakultas Sains dan Teknologi, Universitas Insan Budi Utomo, Indonesia
Email: wilyanti310875l@gmail.com, alfianti_hasanah@uibu.ac.id, ririn_ningkeula@uibu.ac.id

ABSTRACT
Given technological advancements, innovation is required to better tailor project-based learning to students who are predominantly "digital natives." Consequently, combining project-based learning with technology offers an ideal solution, particularly within the context of higher education. Blended project-based learning enables students to access materials, engage in discussions, and complete coursework and projects—whether face-to-face or virtually, and through both synchronous and asynchronous modes. The application of blended project-based learning allows for the integration of technology, thereby enriching the teaching and learning process and motivating learners to participate actively. The hypothesis proposed is that there is a significant difference in conceptual understanding between the group using the blended project-based learning strategy and the group using the project-based learning strategy. The findings of this study indicate a difference in students' conceptual understanding between those taught using the blended project-based learning strategy and those taught using project-based learning. It is advisable to possess technological proficiency, a strong willingness to learn, and a sense of curiosity. These qualities are crucial for the success of the blended learning process, given that blended learning is an instructional strategy that operates across various contexts and timeframes.

***Keywords**: Blended project-based learning, project-based learning, understanding of chemistry concepts*

JIPTEK: Jurnal Ilmiah Pendidikan Teknik dan Kejuruan
Vol 19 Issue 2 2026
DOI: https://doi.org/10.20961/jiptek.vyyix.xxxxx

INTRODUCTION

Technological advancements in the Industrial Revolution 4.0 era have transformed the ways people live, learn, and work (Chase & Klahr, 2017; Fauzi, 2019), thereby shifting the demand for 21st-century skills. This revolution has spurred the emergence of network-based education. Recognizing that today's learners—belonging to the post-millennial generation—are highly tech-savvy presents an opportunity that should be harnessed to enhance the academic quality of school-based learning. Therefore, innovation is needed to leverage existing potential and systems to foster 21st-century competencies among students and encourage them to become lifelong learners by utilizing technology in their academic activities. Achieving conceptual understanding requires specific strategies tailored to the characteristics of the students and the learning material. These learning strategies encompass approaches to organizing subject matter and content, as well as methods for delivering material to students—strategies that involve the use of instructional media and technology. And management strategies—covering both the management of instruction and the management of media (N.S. Degeng, 2013). The use of learning strategies is a crucial element of the teaching-learning process (Chase & Klahr, 2017; Fauzi, 2019), and this aspect continues to evolve alongside technological advancements; furthermore, regarding the future of learning, research in instructional technology is likely to focus on how the interaction between condition and method variables influences learning objectives (Degeng, 1989). As a student-centered method of instruction, Project-Based Learning (PBL) encourages students to draw on a wide range of experiences to build their knowledge and apply what they've learned (Maskell & Grabau, 1998).

Project-based learning is an approach to education that places students at the center and is based on contextual learning principles, involving active student participation to achieve learning objectives through interaction and knowledge sharing (Kokotsaki et al., 2016; Guribie et al., 2021). Project-based learning is a student-centered learning process grounded in contextual learning principles, involving active student participation to achieve learning objectives through interaction and knowledge sharing (Kokotsaki et al., 2016; Guribie et al., 2021). The use of a blended learning-based project-based learning strategy provides students with opportunities to access materials, engage in discussions, and complete coursework and projects—whether face-to-face or virtual, synchronous or asynchronous (Ma, 2016; Adri, 2020; Alamri, 2021; Putra et al., 2021).

Previous research findings indicate that blended incorporating projects into teaching methods influences learning outcomes (Lou et al., 2012; Klentien & Wannasawade, 2016; Aliftika et al., 2021). This research aims to investigate the difference in conceptual understanding between the group using the blended as well as the class that uses this method of instruction.

RESEARCH METHODS

The researchers used a "quasi-experimental non-equivalent control-group" approach, a framework devised by the researcher to address the research question. Under this design, subjects are assigned to treatment groups based on existing classroom conditions rather than through random assignment (P. Setyosari, 2013). The research subjects were Mechanical Engineering students from the 2024/2025 cohort taking the Basic Chemistry course. A total of 80 students from the Mechanical Engineering study program participated in the study. The sample was drawn from two classes and forty students each served as an experimental group and a control group. The researchers developed a conceptual understanding test instrument to measure students' level of conceptual understanding both before and after acquiring new knowledge. When using the instrument prior to instruction is intended to assess their grasp of the concepts. Meanwhile, the final conceptual understanding test was administered to measure the impact of the implemented learning strategy on students' understanding of concepts. The test consisted of multiple-choice questions. 20 Multiple-Choice Questions.

The instruments were used in the actual study, and all research instruments underwent pilot testing. The test items were developed, adapted, and revised prior to being used for data collection.

RESULTS OF RESEARCH AND DISCUSSION

The administered both the pre- and post-tests conducted to gather data for subsequent analysis to test the following hypotheses: (1) whether there is a significant difference in Basic Chemistry concept comprehension between the class using the Blended Project-Based Learning strategy and the class using Project-Based Learning; and (2) whether there is an interaction between the Blended Project-Based Learning and Project-Based Learning strategies regarding concept comprehension ability.

Table 1. Pre-test Score Data on Biochemistry Concept Understanding Based on Learning Strategies

Learning strategies	N	Mean	Std. Deviatio
Blended project based learning	40	66,4583	13,36635
Project based learning	40	61,3750	11,58941

Table 1 shows that the difference in the mean pretest scores for Basic Chemistry concept understanding, based on the learning strategy, is 5.0833.

Table 2. Posttest Score Data for Basic Chemistry Concept Understanding Based on Learning Strategy

Learning strategies	N	Mean	Std. Deviatio
Blended project based learning	40	75,2083	12,97152
Project based learning	40	63,1667	11,92808

Following experiments using the Blended Project-Based Learning and Project-Based Learning strategies, it was found that the average scores for Basic Chemistry concept understanding—based concerning the pre- and post-test results—increased under both instructional strategies. The average post-test score for Basic Chemistry concept understanding was 75.2083 for the Blended Project-Based Learning strategy, whereas it was 63.1667 for the Project-Based Learning strategy. The difference between the two instructional strategies is 12.0416. Based on the pre-test and post-test results regarding the implementation of the learning strategies, it was found that both classes showed score improvements following the experiment. In addition to the score increases, the gap between the scores associated with the two strategies narrowed; specifically, the score difference was 5.0833 at the pre-test stage, whereas the post-test difference was 12.0416. Analysis of Pre-test Scores Based on Learning Strategy. The results of the mean difference test for Basic Chemistry concept understanding scores based on learning strategy are presented in Table 1. If the significance value (sig.) is > 0.05, then the null hypothesis (Ho) is accepted (indicating no significant difference in Basic Chemistry concept understanding between the class using the blended class that is using a project-based learning approach, and the approach itself. The first hypothesis is that a significant difference in conceptual understanding between the group using the blended as well as the class that uses this method of instruction.

Table 3. Mean Score Test for Basic Chemistry Concept Understanding Based on Learning Strategy

		Levene's Test for Equality of Variances	
		F	Sig.
Conceptual Understanding	Equal variances assumed	2,477	,120
	Equal variances not assumed		

Analysis of variance regarding conceptual understanding using Levene’s test yielded an alpha level of 0.120, which is higher than the threshold of 0.05. As a result, we accept the null hypothesis, indicating class to class in terms of conceptual understanding of basic chemistry using the learning strategies employed. blended collaborative learning and collaborative learning via projects strategies.

Table 4. Normality Test of Concept Understanding Scores based on Learning Strategies

	Learning strategies	Kolmogorov-Smirnova		
		Statistic	df	Sig.
Conceptual Understanding	*Blended project based learning*	1,383	40	0,054
	Project based learning	0,463	40	0,983

The Kolmogorov-Smirnov test results for the understanding of Basic Chemistry concepts—using Blended Project-Based Learning and Project-Based Learning strategies, respectively—yielded significance values of 0.054 and 0.983. Since the test results indicate significance levels greater than 0.05, it can be concluded that the data on conceptual understanding scores, categorized by learning strategy, are normally distributed.

Table 5. Homogeneity of Variance Test for Conceptual Understanding Scores

		Levene Statistic	*Sig.*
Conceptual Understanding	*Based on Mean*	,365	548
	Based on Median	,027	,870
	Based on Median and with adjusted df	,027	,870
	Based on trimmed mean	*,218*	*,642*

Based on the calculation results in point 4 above, the mean score for Basic Chemistry concept understanding is 0.365, having a p-value of 0.548. What this means is that the data originate from a population with equal variances (homogeneity), as the value exceeds 0.05. A significance value greater than 0.05 is also observed when measurements are based on the median, yielding a value of 0.870. This study's null hypothesis states that nobody noticed a change in the ability to understand Basic Chemistry concepts among the classes that used a hybrid approach to project-based learning and those that used a traditional approach and project-based learning strategy. The findings of the MANOVA test, the probability value is 0.000, and the calculated F-value is 32.879. This indicates that the p-value is less than 0.05. It follows that H1 is really approved. The according to the findings of this investigation, trainees' conceptual understanding taught using incorporated PBL into a mixed learning environment. In a blended PjBL approach, students can study foundational material online prior to face-to-face sessions. In the classroom, more time is dedicated to: discussions, experiments, problem-solving, project development. This allows for a more effective use of face-to-face time. Blended project-based learning, (Rifda Eliyasni et al., 2019), is a state-of-the-art approach to education that teaches a variety of 21st-century critical thinking skills. By asking questions, working together on research, and creating projects that showcase their knowledge, students actively participate in their own learning. This kind of instruction helps students in many ways; they develop imaginative and practical technical skills, as well as strong communication and problem-solving abilities. Blended project-based learning forms the backbone of this curriculum, with reading, writing, and arithmetic making up the bulk of the tasks.

Improved subject-matter comprehension, more in-depth learning, more advanced reading, and a stronger intrinsic motivation to study are all results of blended project-based learning—a model that enhances students' knowledge and skills regarding collaborative work (Aliftika et al., 2021). This view aligns with findings (Oliver & Trigwell, 2005; García-Valcárcel & Basilotta Gómez-Pablos, 2016) indicating that integrating blended learning models enables students to become increased levels of engagement, conversation, and participation in their studies while expanding their knowledge. This is because blended learning has several benefits, including as allowing for more individualized lessons and encouraging students to work together in groups as well as independently, enhancing lecturer engagement in education, and offering flexibility—allowing for learning anytime and anywhere (Nurhayati et al., 2021)—while serving as a pedagogical method that accommodates individual learning styles. This process takes place in an interactive learning environment that combines virtual settings with face-to-face methods to achieve learning objectives. Blended project-based learning is a key approach to encouraging students to become critical thinkers and learners. The students take the initiative to plan their own studies, come up with their own questions, and utilize various pedagogical resources for addressing practical issues (Alamri, 2021). This effectiveness is evident in the online learning process, which allows students to study anytime and anywhere, unrestricted by space or time. Another positive aspect is that if students—or group members assigned specific task responsibilities—encounter difficulties, they can directly discuss the issues with one another. Meanwhile, in the control group—which utilized a project-based learning strategy—the structure served merely to assist and guide students in completing tasks within the time constraints of a single virtual meeting (Ceylan & Elitok Kesici, 2017). It follows from this study's results and the references that they provide blended project-based learning is effective in enhancing students' understanding of Basic Chemistry concepts. This effectiveness is evident in the learning process conducted online, allowing students to learn anytime and anywhere, without being constrained by space or time. Another positive aspect of the blended project-based learning strategy is that if a group encounters difficulties, discussions can continue—either synchronously or asynchronously—with the instructor present in the learning group; the use of diverse learning spaces and student-to-student interaction greatly aids students in grasping the concepts being studied. Thus, blended project-based learning—which enables learning anytime and anywhere, free from spatial and temporal constraints—can enhance conceptual understanding, as learners are able to review the material repeatedly without time limits. In contrast, for the control group utilizing the project-based learning strategy, the structure provided to assist and guide task completion was constrained by space and time, with learning limited to scheduled virtual sessions (Nabeth et al., 2004).

Blended project-based learning is crucial for instruction and for enhancing student engagement by working together and interacting with others. Thus, it would be wise to think about using the blended project-based learning approach in higher education.

Budiyanto et. al. (2021). While the writing at the end of the sentence from the authors of three or more is like this (Budiyanto et. al, 2021). Note that if the author is made part of the narrative, then the author's name is placed outside the parenthetical punctuation "( )".

CONCLUSIONS AND SUGGESTIONS

Conclusion

There is a difference in conceptual understanding in the classroom when students work in small groups on integrated projects strategy and those using project-based learning in the Basic Chemistry course.

Suggestion

Students participating in a blended learning process are encouraged to possess technological proficiency, a strong willingness to learn, and a sense of curiosity. These attributes are crucial for the success of the blended learning process, given that it is a strategy that operates across different contexts and timeframes.

REFERENCE

Adri, M. (2020). Using ADDIE instructional model to design blended project-based learning based on production approach. *International Journal of Advanced Science and Technology*, *29*(6), 12.

Alamri, M. M. (2021). Using blended project-based learning for students' behavioral intention to use and academic achievement in higher education. *Education Sciences*, *11*(5), 207. https://doi.org/10.3390/educsci11050207

Aliftika, O., Astra, I. M., & Supriyati, Y. (2021). Project based blended learning and independent learning on critical thinking skill. *Journal of Physics: Conference Series*, *2019*(1), 012051. https://doi.org/10.1088/1742-6596/2019/1/012051

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3–4), 369–398. https://doi.org/10.1080/00461520.1991.9653139

Ceylan, V. K., & Elitok Kesici, A. (2017). Effect of blended learning to academic achievement. *Journal of Human Sciences*, *14*(1), 308. https://doi.org/10.14687/jhs.v14i1.4141

Chase, C. C., & Klahr, D. (2017). Invention versus direct instruction: For some content, it's a tie. *Journal of Science Education and Technology*, *26*(6), 582–596. https://doi.org/10.1007/s10956-017-9700-6

Degeng, N. S. (2013). *Ilmu pembelajaran (Klasifikasi variabel untuk pengembangan teori dan penelitian)* [Learning science (Variable classification for theory development and research)]. Bandung: Aras Media.

Eliyasni, R., Kenedi, A., & Sayer, I. (2019). Blended learning and project based learning: The method to improve students' Higher Order Thinking Skill (HOTS). *Jurnal Iqra': Kajian Ilmu Pendidikan*, *4*(2). https://doi.org/10.25217/ji.v4i2.549

Ergül, N. R., & Kargın, E. K. (2014). The effect of project based learning on students' science success. *Global Conference on Linguistics and Foreign Language Teaching (Linelt-2013)*, *136*, 537–541. https://doi.org/10.1016/j.sbspro.2014.05.371

García-Valcárcel, A., & Basilotta Gómez-Pablos, V. (2016). Aprendizaje basado en proyectos (ABP): Evaluación desde la perspectiva de alumnos de Educación Primaria [Project-based learning (PBL): Evaluation from the perspective of primary education students]. *Revista de Investigación Educativa*, *35*(1), 113. https://doi.org/10.6018/rie.35.1.246811

Klentien, U., & Wannasawade, W. (2016). Development of blended learning model with virtual science laboratory for secondary students. *Procedia - Social and Behavioral Sciences*, *217*, 706–711. https://doi.org/10.1016/j.sbspro.2016.02.126

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, *19*(3), 267–277. https://doi.org/10.1177/1365480216659733

Lou, S.-J., Chung, C.-C., Dzan, W.-Y., & Shih, R.-C. (2012). Construction of a creative instructional design model using blended, project-based learning for college students. *Creative Education*, *3*(7), 1281–1290. https://doi.org/10.4236/ce.2012.37187

Ma, H. (2016). A study of blended learning strategies for project-based studies. *Journal of Blended Learning*, 8.

Maskell, D. L., & Grabau, P. J. (1998). A multidisciplinary cooperative problem-based learning approach to embedded systems design. *IEEE Transactions on Education*, *41*, 101–103.

Miller, J. D. (1998). The measurement of civic scientific literacy. *Public Understanding of Science*, *7*(3), 203–223. https://doi.org/10.1088/0963-6625/7/3/001

Nabeth, T., Angehrn, A., & Balakrishnan, R. (2004). Integrating context in elearning systems design. In *Proceedings—IEEE International Conference on Advanced Learning Technologies, ICALT 2004* (p. 359). https://doi.org/10.1109/ICALT.2004.135743

Nurhayati, E., Rizaldi, D. R., & Fatimah, Z. (2021). The effectiveness of project-based learning with the blended learning system to improve 21st century skills during the COVID-19 pandemic. *Jurnal Pendidikan*, *9*(2), 7.

Oliver, M., & Trigwell, K. (2005). Can "blended learning" be redeemed? *E-Learning and Digital Media*, *2*(1). https://doi.org/10.2304/elea.2005.2.1.17

Pramanik, A., Islam, M. N., Basak, A. K., & Dong, Y. (2019). Chapter 3—Learning enhancement of project-based unit in mechanical engineering undergraduate course. In J. P. Davim (Ed.), *Manufacturing Engineering Education* (pp. 73–84). Chandos Publishing. https://doi.org/10.1016/B978-0-08-101247-5.00003-4

Putra, A. K., & Sumarmi, S. (2021). The effect of blended project-based learning with STEM approach to spatial thinking ability and geographic skill. *International Journal of Instruction*, *14*(3), 685–704. https://doi.org/10.29333/iji.2021.14340a

Widiyanti, Marsono, Eddy, D. L., & Yoto. (2020). Project-based learning based on STEM (Science, Technology, Engineering, and Mathematics) to develop the skill of vocational high school students. In *2020 4th International Conference on Vocational Education and Training (ICOVET)* (pp. 123–126). https://doi.org/10.1109/ICOVET50258.2020.9230088