THE EFFECTIVENESS OF PROBLEM-BASED LEARNING IN OBJECT-ORIENTED PROGRAMMING INSTRUCTION: A CLASSROOM ACTION RESEARCH STUDY

Elva Hidayatul Haque[1*], Slamet Wibawanto[2*], Winda Sulistyana[3]

[1] PPG Sekolah Pascasarjana Universitas Negeri Malang
[2] Teknologi Rekayasa Pembangkit Energi Fakultas Vokasi Universitas Negeri Malang
Jl. Semarang No. 5 Malang, Jawa Timur, Indonesia
[3] SMKN 9 Malang
Jl. Sampurna No.1, Cemorokandang, Kec. Kedungkandang, Malang, Jawa Timur, Indonesia
*Corresponding author, email: slamet.wibawanto.ft@um.ac.id

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Abstract
This study aims to examine the implementation of object-oriented programming (OOP) instruction using a Problem-Based Learning (PBL) approach to enhance students' programming skills at SMKN 9 Malang. The research employed a Classroom Action Research (CAR) design conducted through three iterative cycles to systematically improve the learning process. The first cycle focused on the planning stage, in which learning objectives, instructional materials, and problem-oriented learning strategies aligned with OOP concepts were developed. The second cycle involved the implementation of the PBL approach, where students actively engaged in solving contextual programming problems requiring the application of object-oriented principles. During this stage, observations were conducted to monitor student participation, learning activities, and skill development, as well as to gather feedback on instructional effectiveness. The third cycle emphasized reflection, in which learning outcomes were evaluated based on students' performance and observational data, followed by instructional refinements to enhance learning effectiveness. The findings indicate that the implementation of OOP instruction through a PBL approach significantly improves students' programming skills. Students demonstrated a deeper understanding of OOP concepts, improved problem-solving abilities, and stronger collaborative skills. This study contributes to the development of innovative instructional practices in information and communication technology education and provides practical guidance for teachers in implementing student-centered programming instruction.

Introduction

The rapid advancement of information and communication technology requires vocational high school (Sekolah Menengah Kejuruan/SMK) graduates to possess competencies that align with the demands of the industrial sector, particularly in the field of programming (Aditama et al., 2025). One of the core competencies that must be mastered by students in the Software Engineering program is Object-Oriented Programming (OOP) (Lutz, 2025; Qu et al., 2025). OOP emphasizes not only syntactic proficiency but also a deep understanding of abstract concepts such as encapsulation, inheritance, and polymorphism, which form the foundation of modern software development. Therefore, OOP instruction must be designed effectively to comprehensively enhance students' programming skills.

SMKN 9 Malang, as one of the vocational high schools in Malang City, East Java, recognizes the importance of strengthening students' programming competencies to prepare them for the

challenges of the digital workforce. However, programming instruction in vocational schools continues to face several challenges. Conventional, teacher-centered instructional methods that emphasize theoretical content delivery often make it difficult for students to apply OOP concepts in real-world contexts. As a result, students tend to struggle with writing program code, debugging, and developing programming solutions that address authentic problems (Retnoningsih et al., 2017). These conditions indicate the need for more contextual and practice-oriented instructional innovations.

One instructional approach considered relevant to addressing these challenges is Problem-Based Learning (PBL). PBL emphasizes student-centered learning through the presentation of authentic problems as triggers for learning (Kunwar, 2025). Through PBL, students are encouraged to actively identify problems, seek relevant information, design solutions, and reflect on learning outcomes both independently and collaboratively (Nafiah & Suyanto, 2014). In the context of object-oriented programming instruction, PBL enables students to connect OOP concepts with real-world programming problems, thereby making learning more meaningful and applicable.

Previous studies have demonstrated the effectiveness of PBL and project-based learning models in improving programming competencies among vocational high school students. Rahman and Ekohariadi (2025) found that the development of the "Edupro" plugin based on Project-Based Learning within the Moodle platform significantly improved object-oriented programming competencies among eleventh-grade Software Engineering students. Similarly, Yanti and Ekohariadi (2024) reported that the implementation of PBL-based e-learning significantly enhanced students' problem-solving skills in OOP courses. Comparable findings were reported by Swari et al. (2015), who concluded that PBL supported by job sheets effectively improved students' learning outcomes in web programming. Furthermore, studies by Ma'rifah et al. (2019) and Nurhidayati et al. (2022) confirmed that PBL supported by student worksheets and e-modules positively contributed to improvements in learning outcomes, student engagement, and learner autonomy in programming instruction.

Despite these positive findings, most existing studies have primarily focused on the development of instructional media or learning tools, with relatively limited attention given to the direct implementation of OOP classes using a PBL approach through Classroom Action Research (CAR). In fact, CAR enables teachers to systematically reflect on instructional practices and implement continuous improvements based on real classroom conditions. Therefore, further research is needed to examine how the implementation of PBL in OOP classrooms can progressively and systematically enhance students' programming skills.

Based on this background, this study is entitled "The Effectiveness of Problem-Based Learning in Object-Oriented Programming Instruction: A Classroom Action Research Study" This research aims to explore the implementation of PBL in OOP instruction at SMKN 9 Malang and to analyze improvements in students' programming skills, including conceptual understanding, practical competence, and the development of soft skills such as collaboration and problem-solving. The findings of this study are expected to contribute theoretically to the development of programming instructional models and to provide practical guidance for vocational school teachers in improving the quality of problem-based programming instruction.

Methods

This study employed a Classroom Action Research (CAR) approach conducted with students of class XII RPL 2. The instructional content focused on Object-Oriented Programming (OOP), specifically on the topic of string data manipulation, including substring, concat, length, replace, uppercase, and lowercase. The learning process was implemented using the Problem-Based Learning (PBL) model as an effort to improve students' programming skills.

Classroom Action Research is a research method aimed at improving the quality of teaching and learning through iterative cycles consisting of planning, action, observation, and reflection (Anshori, 2016; Prihantoro & Hidayat, 2019). In the planning stage, the researcher, who also acted as the teacher, formulated specific learning objectives based on the targeted basic competencies. In addition, problem-based learning scenarios were designed to emphasize the application of OOP concepts in string data manipulation. The problems were contextual in nature to encourage students to think critically and to develop programming solutions independently or collaboratively.

The action stage involved the implementation of PBL in the classroom. The teacher introduced programming problems related to string data manipulation, after which students were required to analyze the problems, design solutions, write OOP-based program code, and test the programs they developed. During the learning process, observations were conducted to monitor students' engagement, problem-solving abilities, and skills in applying OOP concepts. Observational data were also used to identify learning obstacles encountered by students and served as a basis for reflection and improvement in subsequent cycles (Cahya & Sucahyo, 2021).

The reflection stage was carried out by evaluating the learning outcomes based on observational data and the results of students' programming skills assessments. Reflection aimed to assess the effectiveness of the PBL implementation in improving object-oriented programming skills and to determine necessary revisions for the next cycle. The CAR process was conducted iteratively until optimal improvement in students' programming skills was achieved.

The research instrument consisted of an OOP-based programming skills assessment rubric. The assessment focused on three main indicators: (1) the ability to develop OOP-based programs in accordance with string data manipulation tasks, (2) the ability to apply string data manipulation following OOP principles using the Java programming language, and (3) the ability to use combinations of string data types according to task instructions. Each indicator was assessed using a scale of 1–3, where a score of 3 represented the highest level of achievement.

Students' final programming skills scores were calculated using the following formula:

$$\text{Final Score} = \text{Total Indicator Score} \times 4$$

The resulting scores were then categorized into levels of object-oriented programming proficiency: very good (91–100), good (81–90), fair (71–80), and poor (≤70). Through this procedure, improvements in students' programming skills were systematically analyzed across each CAR cycle.

Results

The results of the Classroom Action Research conducted with students of class XII RPL 2 at SMKN 9 Malang indicate a consistent improvement in students' object-oriented programming (OOP) skills after the implementation of the Problem-Based Learning (PBL) model. Programming skills were assessed using three main indicators, as presented in Table 1: (1) the ability to

develop OOP-based programs according to string data manipulation tasks, (2) the ability to apply string data manipulation in accordance with OOP principles using the Java programming language, and (3) the ability to use combinations of string data types based on task instructions.

Table 1. Student Learning Mastery Data in PBL-Based OOP Learning

No	Indicator	Score	Assessment Criteria	Cycle I (F/%)	Cycle II (F/%)	Cycle III (F/%)
1	Developing OOP-based programs according to string data manipulation	3	Able to develop OOP-based programs according to string data manipulation tasks accurately and neatly	1 / 64%	15 / 100%	20 / 100%
		2	Able to develop OOP-based programs correctly, but with less neat code structure	22 / –	21 / –	16 / –
		1	Able to develop OOP-based programs, but not yet aligned with string data manipulation	13 / –	0 / –	0 / –
2	Applying string data manipulation	3	Able to apply string data manipulation and OOP concepts correctly using Java	15 / 42%	10 / 97%	17 / 100%
		2	Able to apply string data manipulation, but not fully aligned with OOP concepts in Java	21 / –	25 / –	19 / –
		1	Able to apply string data manipulation, but inconsistent with OOP concepts and Java structure	0 / –	1 / –	0 / –
3	Using combinations of string data types	3	Able to use combinations of string data types according to task instructions	16 / 44%	7 / 86%	11 / 100%
		2	Able to use combinations of string data types, but not in accordance with task instructions	20 / –	24 / –	25 / –
		1	Able to use combinations of string data types, but with inaccurate application of OOP and Java concepts	0 / –	5 / –	0 / –

Based on Table 1, there is a clear improvement in students' learning mastery across all indicators in each cycle. In Cycle I, most students were still categorized at scores 1 and 2, indicating that their understanding of OOP concepts and string manipulation was not yet optimal. After the implementation of the Problem-Based Learning approach in Cycle II, the number of students achieving a score of 3 increased significantly across all indicators. The most notable improvement was observed in the indicators related to developing OOP-based programs and applying string data manipulation.

In Cycle III, all indicators reached 100% mastery, demonstrating that the implementation of an object-oriented programming class using the PBL approach was effective in improving vocational high school students' programming skills. These findings suggest that PBL provides meaningful learning experiences that support students in understanding OOP concepts,

enhancing problem-solving abilities, and applying programming knowledge in a systematic and practical manner.

Discussion

The improvement in learning outcomes presented in Table 1 indicates that the implementation of the Problem Based Learning (PBL) model was effective in enhancing the object-oriented programming skills of students in class XII RPL 2 at SMKN 9 Malang. In Cycle I, the relatively low level of learning mastery was primarily caused by students' limited initial understanding of basic OOP concepts and string data manipulation, as well as their lack of experience in solving contextual programming problems. Learning activities that were previously dominated by theoretical explanations made it difficult for students to apply concepts in practical programming tasks. This finding is consistent with Retnoningsih et al. (2017), who argue that theory-oriented programming instruction often hinders students' ability to implement concepts effectively in real practice (Razali et al., 2025).

Based on the reflection results from Cycle I, instructional improvements in Cycle II focused on presenting more contextual problems, providing relevant real-world case examples, and increasing discussion and collaborative group activities. The PBL approach encouraged students to actively analyze problems, design solutions, implement program code, and test the results of their work. These learning conditions led to a significant improvement in students' programming skills, as reflected in the increased percentage of mastery across all assessment indicators. This finding supports the results of Nafiah and Suyanto (2014), who reported that PBL effectively enhances students' critical thinking skills and learning outcomes.

In Cycle III, students demonstrated a higher level of independence and were able to complete programming tasks more systematically (Fan et al., 2025). The achievement of 100% learning mastery across all indicators indicates that students were able to optimally integrate OOP concepts with string data manipulation. This result aligns with previous studies by Rahman and Ekohariadi (2025) as well as Yanti and Ekohariadi (2024), which emphasize that problem-based and project-based learning approaches significantly improve object-oriented programming competencies among vocational high school students.

Thus, Table 1 serves as empirical evidence that the implementation of object-oriented programming classes using the Problem Based Learning model not only improves students' technical programming skills but also contributes to the development of essential soft skills, such as collaboration, communication, and problem-solving abilities. These competencies are highly relevant to the demands of the information technology industry, which increasingly values critical thinking and collaborative work skills.

Research Limitations

This study has several limitations that should be considered to properly interpret the scope and findings of the research. First, the study was limited to the implementation of object-oriented programming instruction using the Problem Based Learning approach at SMKN 9 Malang, with participants drawn from only one class, namely class XII RPL 2. Therefore, the findings cannot be generalized to all vocational high schools or other areas of expertise.

Second, the learning material examined in this study was restricted to string data manipulation competencies within object-oriented programming using the Java programming language.

Other programming topics, such as advanced data structures, database systems, or graphical user interface development, were not included in the scope of this research.

Third, this study employed Classroom Action Research (CAR) conducted over three cycles, consisting of planning, action, observation, and reflection stages. As a result, improvements in students' programming skills were measured based on short-term learning outcomes within each cycle, and the long-term effects of implementing the PBL model were not examined.

Fourth, the indicators of research success were limited to improvements in students' programming skills as measured by learning mastery and task performance in OOP-based programming activities. External factors such as students' learning motivation, prior programming experience, and learning support outside the classroom were not analyzed in depth.

Despite these limitations, this study provides meaningful empirical insights into the effectiveness of implementing Problem Based Learning in object-oriented programming instruction to enhance vocational high school students' programming skills.

Research Impact

The findings of this study have several important implications for vocational education, particularly in the teaching of object-oriented programming (OOP) at vocational high schools. First, this research demonstrates that the implementation of the Problem Based Learning (PBL) model has a positive impact on improving students' programming skills in a structured and measurable manner. The consistent increase in learning mastery across the three research cycles indicates that PBL effectively supports students in understanding abstract OOP concepts and applying them to practical programming tasks. This impact is particularly significant in vocational education, where learning outcomes are closely aligned with industry-oriented competencies.

Second, this study contributes to pedagogical practice by providing empirical evidence that PBL can be effectively implemented through Classroom Action Research (CAR). The cyclical process of planning, action, observation, and reflection enables teachers to continuously refine instructional strategies based on real classroom conditions. As a result, this research encourages teachers to adopt reflective and adaptive teaching practices when delivering complex technical subjects such as programming.

Third, beyond technical competencies, the implementation of PBL in OOP instruction positively influences students' soft skills development. Students were observed to demonstrate improved collaboration, communication, problem-solving, and self-directed learning abilities throughout the learning process. These skills are essential for students' future careers in the information technology sector, where teamwork and analytical thinking are as important as technical proficiency.

Finally, at the institutional level, this research provides a practical reference for schools in designing more contextual and student-centered programming instruction. The successful implementation of PBL in this study can serve as a model for other vocational schools seeking to enhance the quality of programming education and better align learning processes with the demands of the digital workforce. Overall, the impact of this research extends beyond classroom improvement, offering meaningful contributions to instructional innovation and vocational education development.

Conclusion

Based on the findings of the Classroom Action Research conducted with students of class XII RPL 2 at SMKN 9 Malang, it can be concluded that the implementation of object-oriented programming instruction on string data manipulation through the Problem Based Learning (PBL) model is effective in improving students' programming skills. The learning process, which was carried out progressively over three cycles, demonstrated a consistent improvement across all assessment indicators, including students' ability to develop OOP-based programs, apply string data manipulation, and use combinations of string data types in accordance with OOP principles. The PBL approach encouraged students to actively engage in problem-solving activities, discussions, and collaborative work, resulting in a deeper understanding of programming concepts. The final results in Cycle III showed that all students achieved learning mastery with a completion rate of 100%, confirming that PBL facilitates effective, contextual, and student-centered learning in vocational programming education.

Based on these findings, future research is recommended to extend the application of the Problem Based Learning model to other programming topics, such as data structures, database-oriented programming, or graphical user interface development, in order to obtain a more comprehensive understanding of the effectiveness of PBL in programming instruction. Subsequent studies may also involve multiple classes or schools to broaden the scope and enhance the generalizability of the results. In addition, future research is encouraged to integrate PBL with other instructional models or supporting technologies, such as learning management systems or online programming platforms, and to include instruments that measure affective aspects and learning motivation. Such efforts would enable a more holistic and in-depth evaluation of the impact of PBL on students' learning outcomes.

References

Aditama, W., Elmunsyah, H., & Umami, A. A. (2025). Optimalisasi Kreativitas Siswa melalui Model Pembelajaran PjBL dengan Keterlibatan Aktif dalam Mata Pelajaran Pemrograman Berbasis Objek. *Journal of Innovation and Teacher Professionalism*, *3*(3), 759–767. https://doi.org/10.17977/um084v3i32025p759-767

Anshori, S. (2016). Pengembangan profesionalisme guru dalam pembelajaran IPS melalui penelitian tindakan kelas di SD Pagotan I Kecamatan Geger Madiun. *Edueksos: Jurnal Pendidikan Sosial & Ekonomi, 2*(1). https://doi.org/10.24235/edueksos.v2i1.623

Cahya, R. E., & Sucahyo, I. (2021). Pengembangan LKPD simulasi *wave on string* untuk pembelajaran gelombang stasioner di SMA. *PENDIPA Journal of Science Education, 5*(3), 366–371. https://doi.org/10.33369/pendipa.5.3.366-371

Fan, G., Liu, D., Zhang, R., & Pan, L. (2025). The impact of AI-assisted pair programming on student motivation, programming anxiety, collaborative learning, and programming performance: a comparative study with traditional pair programming and individual approaches. *International Journal of STEM Education*, *12*(1), 16. https://doi.org/10.1186/s40594-025-00537-3

Kunwar, S. (2025). Student Learning in Problem-Based Learning. In *Mastering Problem-Based Learning in Health Profession Programs: Principles, Procedures, and Best Practices* (pp. 83-112). Cham: Springer Nature Switzerland.

Lutz, M. (2025). *Learning python: Powerful object-oriented programming*. " O'Reilly Media, Inc.".

Ma'rifah, S. N., Wijoyo, S. H., & Wicaksono, S. A. (2019). Penerapan problem-based learning berbantuan lembar kerja siswa untuk meningkatkan hasil belajar pada mata pelajaran pemrograman dasar (studi pada: SMK Negeri 4 Malang). *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, 3*(11), 10586–10594. https://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/6730

Megawati, S. (2013). Meningkatkan hasil belajar siswa kelas XI SMK Negeri 1 Parigi pada mata pelajaran IPA Biologi melalui pembelajaran kooperatif model think-pair-share. *Jurnal Kreatif Tadulako, 2*(4), 111–1456.

Nafiah, Y. N., & Suyanto, W. (2014). Penerapan model problem-based learning untuk meningkatkan keterampilan berpikir kritis dan hasil belajar siswa. *Jurnal Pendidikan Vokasi, 4*(1), 125–143. https://doi.org/10.21831/jpv.v4i1.2540

Nurhidayati, E., Wijoyo, S. H., & Herlambang, A. D. (2022). Pengembangan e-modul berbasis model problem-based learning untuk meningkatkan hasil belajar siswa pada mata pelajaran dasar program keahlian kelas X TKJ di SMK Negeri 5 Malang. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, 6*(9), 4586–4596. https://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/11628

Prihantoro, A., & Hidayat, F. (2019). Melakukan penelitian tindakan kelas. *Ulumuddin: Jurnal Ilmu-Ilmu Keislaman, 9*(1), 49–60. https://doi.org/10.47200/ulumuddin.v9i1.283

Qu, Y., Li, F., Dou, X., Feng, C., & Li, B. (2025). Research on Object-Oriented Programming Teaching Evaluation Method Based on Few-Shot Prompt Learning. *Journal of Internet Technology*, *26*(7), 893-900. Retrieved from https://jit.ndhu.edu.tw/article/view/3230

Rahman, G. F., & Ekohariadi, E. (2025). Pengembangan plugin "Edupro" berbasis project-based learning di Moodle untuk meningkatkan kompetensi pemrograman berorientasi objek (studi kasus siswa kelas XI RPL SMKN 1 Surabaya). *IT-Edu: Jurnal Information Technology and Education, 10*(2). https://doi.org/10.26740/it-edu.v10i02.66428

Razali, R., Sundana, L., Ramli, R., Alamsyah, T., & Wahdaniah, W. (2025). Language curriculum development to increase students' interest in communication and literacy in higher education: a qualitative study. *Cogent Education*, *12*(1), 2448349. https://doi.org/10.1080/2331186X.2024.2448349

Retnoningsih, E., Shadiq, J., & Oscar, D. (2017). Pembelajaran pemrograman berorientasi objek (object-oriented programming) berbasis project-based learning. *Informatics for Educators and Professionals: Journal of Informatics, 2*(1), 95–104.

Rojat, M. R. (2023). Pembelajaran pemrograman berorientasi objek (object-oriented programming) berbasis project-based learning. *Jurnal Portal Data*.

Swari, P. K. W., Wirawan, I. M. A., & Sunarya, I. M. G. (2015). Penerapan model pembelajaran berbasis masalah (problem-based learning) berbantuan jobsheet untuk meningkatkan hasil belajar siswa pada mata pelajaran pemrograman web di kelas X TKJ 4 SMK Negeri 3 Singaraja. *KARMAPATI (Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika), 4*(3), 142–154. https://doi.org/10.23887/karmapati.v4i3.6512

Yanti, H. D., & Ekohariadi, E. (2024). Pengembangan e-learning berbasis website dengan model pembelajaran problem-based learning untuk meningkatkan keterampilan pemecahan masalah siswa pada mata pelajaran pemrograman berorientasi objek di SMKN 2 Mojokerto. *IT-Edu: Jurnal Information Technology and Education, 9*(1), 1–7. https://doi.org/10.26740/it-edu.v9i1.58273