

PROJECT-BASED E-LEARNING DEVELOPMENT WITH A MICROLEARNING APPROACH TO IMPROVE PROGRAMMING LEARNING OUTCOMES OF VOCATIONAL HIGH SCHOOL STUDENTS

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Abstrak

Rendahnya hasil belajar pemrograman pada siswa jurusan Rekayasa Perangkat Lunak dipengaruhi oleh keterbatasan media pembelajaran interaktif yang berdampak pada rendahnya motivasi dan keterlibatan belajar. Penelitian ini bertujuan mengembangkan media pembelajaran berbasis proyek melalui e-learning dengan pendekatan microlearning untuk meningkatkan hasil belajar pada mata pelajaran Pemrograman Berorientasi Objek. Pengembangan media dilakukan menggunakan model ADDIE yang meliputi tahap analisis, perancangan, pengembangan, implementasi, dan evaluasi. Subjek penelitian adalah siswa SMKN 1 Sukawati pada program keahlian Rekayasa Perangkat Lunak. Hasil penelitian menunjukkan bahwa media pembelajaran yang dikembangkan memiliki tingkat validitas dan kepraktisan yang sangat tinggi berdasarkan penilaian para ahli dan hasil uji coba kepada siswa. Selain itu, penerapan media pembelajaran ini terbukti mampu meningkatkan hasil belajar siswa dalam kategori yang sangat baik. Temuan penelitian ini mengindikasikan bahwa integrasi pembelajaran berbasis proyek melalui e-learning dengan pendekatan microlearning merupakan solusi yang efektif untuk meningkatkan kualitas pembelajaran pemrograman di jenjang SMK.

Kata Kunci: Pembelajaran Berbasis Proyek; E-learning; Microlearning; Hasil Belajar; Pemrograman Berorientasi Objek

Abstract

The low achievement in programming courses among students in the Software Engineering program is influenced by the limited availability of interactive learning media, which negatively affects students' learning motivation and engagement. This study aims to develop a project-based learning medium delivered through e-learning with a microlearning approach to improve learning outcomes in Object-Oriented Programming courses. The learning media were developed using the ADDIE model, which consists of the analysis, design, development, implementation, and evaluation stages. The research participants were vocational high school students enrolled in the Software Engineering program at SMKN One Sukawati. The findings indicate that the developed learning media demonstrate very high levels of validity and practicality based on expert evaluations and student trial results. Furthermore, the implementation of the learning media was shown to enhance students' learning outcomes with an excellent criteria. These findings suggest that integrating project-based learning through e-learning with a microlearning approach represents an effective solution for improving the quality of programming education in vocational high schools.

Keywords: Project-Based Learning; E-learning; Microlearning; Learning Outcomes; Object-Oriented Programming

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INTRODUCTION

The rapid advancement of information and communication technology has brought substantial changes in educational systems, requiring educational institutions to continuously adapt and optimize the utilization of technology to improve learning quality (Zou et al., 2025). In the digital era, information and communication technology has become an integral part of the learning process and has encouraged the widespread adoption of educational technology. Educational technology represents a systematic effort to enhance learning effectiveness by applying scientifically proven principles across various educational contexts (Bhismantara et al., 2024). The Association for Educational Communications and Technology defines educational technology as both a field of study and a professional practice grounded in ethical principles, focusing on facilitating learning and improving performance through the systematic design, implementation, and management of appropriate technological processes and resources (Heggart et al., 2025). Educational technology encompasses various components, including hardware and software, digital applications, learning management, and the application of innovative pedagogical approaches that contribute to effective and efficient learning across educational levels (Mukul & Büyüközkan, 2023). Therefore, educational technology plays a crucial role in improving learning quality at all levels of education through the integration of technology and appropriate pedagogical approaches to strengthen students' competencies and support the achievement of learning objectives, including in ICT learning.

Vocational High Schools (Sekolah Menengah Kejuruan/SMK) are defined as formal secondary education institutions that focus on developing practical skills through Field Work Practice (PKL) activities to better prepare graduates for the workforce (Santika et al., 2022). In this context, preparing students for PKL, particularly those in the Software Engineering (Rekayasa Perangkat Lunak/RPL) program, requires mastery of programming (coding) skills as a key competency that must be developed and strengthened (Ahmed et al., 2025). Observations at SMK Negeri 1 Sukawati indicate that students' programming skills remain relatively low, as reflected in practical assessment results, where the average practical score of 30 students reached only 64.80. This figure is significantly below the Minimum Mastery Criterion (KKM) set by SMKN 1 Sukawati, which is 75. The low level of programming competence is presumed to be influenced by an unengaging learning environment and instructional materials, leading to decreased student motivation (Azkiya & Ifriza, 2025). This finding is consistent with interview results involving several students at SMKN 1 Sukawati, which revealed that conventional instructional materials that are overly textual and monotonous often make the learning process feel boring. This aligns with studies indicating that vocational students' programming skills remain low due to learning methods that lack contextual relevance and interactivity (Pratama et al., 2023). Students tend to be less actively involved and less motivated when learning relies solely on textbooks; they expect more concise, practical, and visually engaging materials such as videos and infographics, as well as opportunities to directly apply knowledge through real projects. Moreover, students in the Software Engineering program often experience difficulties in understanding concepts such as encapsulation, inheritance, and polymorphism within Object-Oriented Programming (OOP) (Fitriyani, 2021). Similar conditions were observed at SMK Negeri 1 Sukawati, particularly in the Software Engineering department, which emphasizes comprehensive programming instruction. Consequently, innovative learning strategies are urgently needed to address these challenges.

One possible approach is to develop project-based learning by integrating instructional media that incorporate appropriate pedagogical approaches. The application of pedagogical strategies that align with learning needs, subject matter, and student characteristics strongly supports the development of targeted competencies (Suartama et al., 2024). In this regard, project-based

learning is particularly suitable for vocational students at institutions such as SMKN 1 Sukawati, as vocational education emphasizes practical, skill-oriented learning rather than predominantly theoretical approaches found in general education (Mustaqim et al., 2024). In addition, to address low student motivation and support the effective delivery of Object-Oriented Programming content, the microlearning approach can be applied. Microlearning is considered effective because it allows students to understand theoretical concepts while gradually developing skills through measurable projects, making the learning process more flexible and efficient (Santi et al., 2024). Accordingly, along with technological advancements in the digital era, educators can develop integrated interactive learning media to support the learning process (Arimbawa et al., 2024). The development of innovative e-learning-based instructional media that integrate microlearning can increase student motivation and facilitate independent learning, as this approach is designed to be engaging and easily accessible. In this study, e-learning is implemented using the Moodle Learning Management System (LMS), which enables students to access learning materials effectively and efficiently while assisting educators in managing learning activities in a more structured and systematic manner, particularly in the context of Object-Oriented Programming (Wiragunawan, 2022). Integrating microlearning into project-based LMS environments enables modular, interactive, and contextual learning that supports students' gradual understanding of OOP concepts (Diaz-Leyva & Chamorro-Atalaya, 2020). Project-Based Learning positions learners at the center of the learning process through the completion of contextual projects that require analytical skills, decision-making, and the application of knowledge, thereby strengthening understanding and learning skills (Nasrum & Subawo, 2022). Furthermore, project-based learning is closely associated with collaborative product development activities, making learning more engaging and student-centered (Khuluq et al., 2023). The combination of microlearning, which presents concise and easily understood content, with project-based learning is considered particularly suitable for Generation Z vocational students (Santi et al., 2024).

This study aims to develop project-based learning implemented through e-learning with microlearning materials to improve learning outcomes of students in the Software Engineering (RPL) program, specifically in the Object-Oriented Programming (OOP) subject. This approach is designed to support students' independent learning, facilitate educators in monitoring learning progress, and bridge the gap between theory and practice through applicable project-based activities. In addition, this study aligns with ongoing educational digitalization efforts that contribute to strengthening teacher competencies within educational institutions (Hilhamsyah et al., 2024). Thus, the findings of this study are expected to provide empirical contributions to the development of technology-based programming instruction that is adaptive to the learning needs of vocational schools in the digital era.

METHOD

The type of research employed in this study is Research and Development (R&D). This research focuses on the development of project-oriented microlearning using a Learning Management System (LMS). The study adopts the ADDIE model (Figure 1), which consists of several stages, namely analysis, design, development, implementation, and evaluation (Branch & Varank, 2009). The use of the ADDIE model is considered an effective approach for creating instructional media and various types of learning resources, as it provides a systematic and structured framework for instructional design (Fajriah et al., 2023).

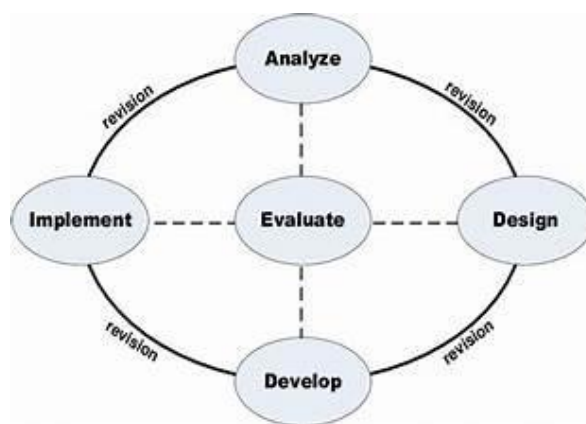


Figure 1. ADDIE Model

This study was conducted at SMK Negeri 1 Sukawati and involved 30 students as research respondents from the Software Engineering (Rekayasa Perangkat Lunak/RPL) department. In addition, the development process involved experts who evaluated the quality of the interface, content, and instructional design of the developed media product. The instruments used to assess the quality of the developed instructional materials consisted of validity and practicality questionnaires, as well as a product effectiveness questionnaire. The validity and practicality instruments comprised three questionnaires with a total of 12 statement items, using a five-point Likert scale, to collect data from both experts and students. Product effectiveness was evaluated through the administration of pretests and posttests to students, consisting of five essay questions designed to measure conceptual understanding and programming skills before and after the use of the project-based interactive learning media. This approach enabled an objective assessment of changes in students' abilities as a result of the implementation of the developed media. Meanwhile, the levels of validity and practicality of the learning media were determined based on the percentage scores obtained from expert evaluations and student trials. The media were categorized as very good if they achieved a percentage score of $\geq 75\%$ and very poor if the score was $\leq 25\%$. These criteria served as the basis for determining the feasibility of the learning media prior to classroom implementation. Improvements in student learning outcomes were analyzed using the normalized gain (N-gain) score to measure instructional effectiveness, along with the learning mastery criteria applied at SMKN 1 Sukawati, where students are considered to have achieved mastery if their scores are ≥ 75 . Learning improvement was classified into three levels—high, medium, and low—based on the N-gain values obtained. The N-gain classification criteria followed the standards proposed by Hake (1999), where a high category corresponds to N-gain ≥ 0.7 and a low category to N-gain < 0.3 . The learning media developed in this study were considered effective if they achieved at least a medium N-gain score, in accordance with the criteria proposed by Agung et al. (2022).

RESULT

Findings from the analysis stage indicate that students experienced difficulties in understanding both theoretical concepts and their application in programming due to the dominance of conventional learning approaches. This condition resulted in low levels of active student engagement in the learning process, causing the expected conceptual understanding and practical skills to develop less optimally. The design stage involved the development of learning content, the structuring of a project-based learning flow, the preparation of media evaluation instruments, and the design of storyboards. In each module, the content was presented in the form of videos, animations, interactive modules, quizzes, and small-scale projects to enhance students' understanding progressively. The learning flow was designed to be systematic and flexible through

the LMS platform to support independent learning. The development stage implemented the designed plans into a tangible product using the Moodle LMS platform. The resulting product was a project-based e-learning prototype that included digital modules, tutorial videos, project worksheets, discussion forums, quizzes, and evaluation components. After the development process was completed, expert validation was conducted to assess the feasibility of the product. The overall evaluation results from the experts indicated that the developed learning media were considered valid and appropriate to be used as an interactive, engaging, and effective learning tool in supporting the improvement of students' learning outcomes, particularly in the Object-Oriented Programming subject. Examples of the developed project-based e-learning with a microlearning approach are presented in Figure 2.



Figure 2. E-Learning Main Page Display

The validity of project-based e-learning was tested with media, learning, and content experts from Ganesha University of Education. The experts involved have expertise in digital learning strategies, digital media and learning resources, and informatics engineering education. The results of the media expert validity test are shown in Table 1.

Table 1. Media Validation Results

No	Aspect	Percentage (%)
1.	E-learning display design	98,00%
2.	E-learning technical	93,33%
3.	Benefits of e-learning	97,50%
Overall total score		116
Maximum score		120
Total percentage		96%
Media validity criteria		Very Good

The assessment results conducted by two media experts showed a total score of 114 out of a maximum score of 120, with a feasibility level of 95 percent, thus categorizing it as very good. This achievement indicates that the project-based e-learning media developed has met feasibility standards in terms of appearance, navigation, text and visual clarity, and ease of use. Furthermore, the validation results for the learning design are presented in Table 2.

Table 2. Learning Design Validation Results

No	Aspect	Percentage (%)
1.	E-learning display design	96,00%
2.	E-learning materials	93,33%
3.	Motivation	100,00%
4.	Operation of e-learning	100,00%
5.	Evaluation	85,00%
Overall total score		113
Maximum score		120
Total percentage		94,16%
Media validity criteria		Very Good

The assessment conducted by learning design experts resulted in a feasibility rating of 94.16 percent, categorized as very good. This finding indicates that the learning design of the project-based e-learning media developed meets feasibility standards in terms of learning planning and design. Furthermore, the results of the material validation are presented in Table 3.

Table 3. Material Validation Results

No	Aspect	Percentage (%)
1.	Curriculum	96,66%
2.	E-learning materials	90,00%
3.	E-learning grammar	100,00%
Overall total score		111
Maximum Score		120
Total Percentage		92,50%
Media validity criteria		Very Good

The evaluation conducted by content experts showed a feasibility level of 92.5 percent, categorized as very good. This finding indicates that the developed learning materials meet basic competencies, have conceptual accuracy, are relevant to learning objectives, and support the implementation of programming projects for vocational high school students. Furthermore, the learning media was tested through individual trials involving three students at SMK Negeri 1 Sukawati. The results of these individual trials are presented in Table 4.

Table 4. Individual Trial Results

No	Aspect	Percentage (%)
1.	E-learning display design	96,00%
2.	E-learning materials	95,55%
3.	Motivation	100,00%
4.	Operation of e-learning	93,33%
5.	Evaluation	100,00%
Overall total score		174
Maximum Score		180
Total Percentage		96,66%
Media validity criteria		Very Good

Based on the calculations, the feasibility level was 96.66 percent, falling into the very good category. This achievement indicates that the developed learning media has met the established quality standards across various assessment aspects. Overall, this learning media was deemed feasible, engaging, and effective for independent use by students in the learning process.

Table 5. Results of Small Group Trial (N=9)

No	Criteria	Score
1.	The display of learning media is attractive and appropriate to the programming material.	40
2.	The menu layout of the media is easy to understand and not confusing.	39
3.	The navigation buttons function properly and are easy to find.	42
4.	The size, color, and type of fonts used are appealing and easy to read.	39
5.	Images, videos, and audio in the media are clear to see and hear.	42
6.	The presentation of the material is well structured and easy to follow.	41
7.	The explanation of the material is clear and easy for students to understand.	45
8.	The examples provided in the media help students understand programming concepts.	41
9.	This media increases my motivation and enthusiasm for learning programming.	37
10.	The learning media is easy to operate and interactive.	43
11.	The evaluation questions in the media are easy to understand and relevant to the material learned.	41
12.	The tasks or evaluations in the media are project-based and encourage students to think creatively.	42
Total score		492
Maximum score		540
Media validity criteria		Very Good

A small group trial of this learning media was conducted on nine 11th-grade RPL students at SMK Negeri 1 Sukawati. The results of the small group trial are shown in Table 5.

The calculation results show an achievement level of 91.11 percent, which is in the very good category. This calculation indicates that the developed learning media received a positive response from students when used in groups. The media was considered to have good appeal, be easy to operate, and be able to help improve students' understanding of the learning material. Next, a field trial was conducted on 30 grade XI students at SMK Negeri 1 Sukawati. The trial procedure began with a pre-test to measure students' initial abilities before using the learning media, then continued with learning activities using the developed media, and ended with a post-test to determine learning outcomes after using the media. The results of the effectiveness test of the developed e-learning media can be seen in Table 6.

Table 6. Effectiveness Test Results

Measurement	Value
Average pre-test	64,80
Average post-test	81,83
N-Gain	0,52

Based on the results of the N-Gain Value test, it was obtained 0.52, which indicates that the increase in student learning outcomes is in the moderate category. Then, the KKM completeness test was conducted based on the pretest-posttest values. The average pre-test score of students was 64.80, while the average post-test score of students after participating in project-based learning through e-learning increased by 81.83, which indicates that the media is not only able to improve learning outcomes, but also helps students achieve the learning completion that has been set. In accordance with the criteria for gain scores and KKM completeness that have been set, it can be said that the project-based learning media through e-learning that was developed is effective in improving student learning outcomes, especially the subjects of this study, namely, students at SMK 1 Sukawati.

DISCUSSION

Research findings indicate that project-based learning media implemented through e-learning with a microlearning approach have a positive impact on the quality of programming instruction at SMKN 1 Sukawati. The developed media not only met feasibility standards but also strengthened the learning outcomes of students in the Software Engineering (RPL) department, particularly in Object-Oriented Programming. These findings are consistent with the studies of Naseer et al. (2025) and Sudarsono et al. (2022), which report that the integration of Project-Based Learning and digital technology enhances motivation, skill development, and work readiness among vocational students. In this study, students reported that microlearning videos and interactive features such as discussion forums and assignment submission tools within the LMS effectively supported collaboration and communication in project-based learning activities. Furthermore, the developed media fulfilled the need for engaging and user-friendly instructional support tools. These findings suggest that the integration of project-based learning, e-learning, and microlearning can create a more meaningful learning environment that aligns with the instructional needs of programming education in vocational institutions such as SMKN 1 Sukawati.

The high levels of feasibility and practicality of the developed learning media can be explained by the application of a microlearning approach within an e-learning environment that emphasizes flexibility, accessibility, and student-centered learning (Bashir & Lapshun, 2025). The presentation of instructional content in short, well-structured learning units supports the gradual understanding of complex programming concepts and contributes to improvements in students'

cognitive, behavioral, and affective domains (Monib et al., 2025). In the context of vocational education, flexible and adaptive e-learning design plays a crucial role in enhancing student engagement, motivation, and learning satisfaction, particularly when instruction is aligned with the characteristics of vocational programs and students' practical learning needs (Forsler et al., 2025; Song & Lai, 2025). Nevertheless, the effectiveness of microlearning largely depends on the relevance of content and learning objectives, making contextual and application-oriented instructional design a key factor in successful implementation (Rof et al., 2024). Therefore, the integration of microlearning into project-based e-learning in this study can be regarded as an effective pedagogical approach that supports usability, learner engagement, and the effectiveness of programming instruction in vocational schools.

Implementation of project-based learning through e-learning plays an important role in improving the quality of programming education in vocational contexts. Through project activities, students are actively involved in designing, implementing, and solving programming-related problems that require direct application of conceptual knowledge, thereby making learning more meaningful compared to traditional instructional approaches. This study aligns with previous research demonstrating that project-based learning is more effective and perceived as more engaging by students than conventional verbal-visual instruction (Maros et al., 2023). In vocational education, project-based learning also emphasizes the development of practical competencies and teamwork skills that are relevant to workforce demands. Prior studies have shown that integrating project-based learning into digital learning environments significantly enhances vocational students' technical competencies and collaborative skills compared to conventional instructional approaches (Tan et al., 2025). Moreover, the success of project-based learning implementation is strongly influenced by pedagogical support and sustainable instructional management, particularly in technology-enhanced learning contexts (Miao et al., 2024). Accordingly, the integration of project-based learning through e-learning in this study can be understood as a relevant pedagogical approach for bridging theory and practice while supporting the contextual development of programming skills among vocational students.

Findings from this study reinforce previous research indicating that the use of e-learning and project-based learning has the potential to enhance instructional quality and student engagement in vocational education. Numerous studies have reported that technology-supported project-based learning promotes active learning, practical skill development, and improved learning outcomes among vocational students across various fields of expertise (Mustaqim et al., 2024; Pratiwi et al., 2024; Rizal et al., 2024). Additionally, studies on microlearning suggest that delivering content through short, digitally based modules can enhance motivation, conceptual understanding, and learner engagement, leading to improved learning outcomes while supporting more personalized and contextual learning experiences (Arimbawa et al., 2025; Silva et al., 2025). These findings are further supported by research demonstrating that microlearning is effective in developing technical skills (Luo & Li, 2025). Beyond supporting conceptual mastery and technical competence, microlearning has also been reported to positively influence learning outcomes and is evaluated favorably by both educators and students, particularly when delivered through structured video-based content. These results strengthen the relevance of microlearning as a supportive approach for digital and project-based learning aimed at improving instructional quality (Hlazunova et al., 2024). Moreover, microlearning is considered effective in supporting project-based learning by providing concise, standardized, and easily accessible content that facilitates knowledge transfer and continuous learning (Beste, 2023). Unlike most previous studies that implemented either project-based learning or microlearning independently, this study systematically developed and integrated project-based e-learning with a microlearning approach in programming instruction at

the vocational high school level, specifically within the Software Engineering program. The integration of microlearning units into structured project activities within the learning management system was designed to address vocational education challenges related to limited competency mastery and student work readiness (Isnaen et al., 2025). Thus, this study successfully demonstrates a systematic integration of project-based e-learning and microlearning to enhance programming education at SMKN 1 Sukawati.

This study contributes theoretically to the field of educational technology through the development of project-based e-learning integrated with a microlearning approach in a vocational education context. The findings confirm that the appropriate combination of pedagogical strategies and technology can create flexible, contextual, and competency-oriented learning environments for vocational students. Practically, the results of this study can serve as a reference for educators and vocational institutions in designing e-learning-based programming instruction that emphasizes not only conceptual mastery but also practical skills and learner autonomy. However, this study has several limitations that should be acknowledged. Differences in students' digital literacy levels and software operation skills, as well as limitations in the quality of devices used by some students, affected the smooth access and optimal utilization of e-learning. Additionally, the use of Moodle as the learning management system presents certain limitations that may influence the depth of analysis of project-based learning processes. Based on these limitations, future research is recommended to consider students' infrastructure readiness and digital literacy, as well as to utilize or combine e-learning platforms with more comprehensive features. In doing so, the development of project-based e-learning integrated with a microlearning approach can be further optimized and tested across broader vocational education contexts.

CONCLUSION

This study resulted in the development of project-based microlearning instructional media implemented through e-learning for students at SMKN 1 Sukawati. The findings indicate that the developed project-based e-learning media with a microlearning approach achieved very high levels of validity and practicality, confirming that the product is suitable for use in the learning process. The results further suggest that the project-based e-learning media are easy to access, practical to use, and aligned with the characteristics and learning needs of vocational high school students. Moreover, the implementation of this learning media was proven effective in improving students' learning outcomes, in line with the principles of project-based learning, the microlearning approach, and previous studies emphasizing the importance of active learning in vocational education. Future research may explore various microlearning designs within project-based learning environments to identify the most effective content structures and instructional strategies for enhancing students' programming skills.

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