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The Implementation of the Project Based Learning Approach in Developing ICT Learning Modules to Enhance SMK Students' Critical Thinking and Problem Solving Skills

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ABSTRACT

The learning module functions as a guide for teachers and students in achieving learning competencies that encompass knowledge, skills, and attitudes. In line with 21st-century learning demands emphasizing the 4C skills (Critical Thinking, Communication, Creative Thinking, and Collaboration), it is essential to develop teaching modules aligned with the characteristics of the Project-Based Learning (PjBL) approach. This study aims to develop a PjBL-based learning module for the Information and Communication Technology (ICT) subject to enhance vocational high school (SMK) students' critical thinking and problem-solving skills. The research employed the Research and Development (R&D) method, with data collected through questionnaires, observations, and documentation involving expert validators and tenth-grade students at SMK Negeri 1 Tulungagung. The stages in this research start from collecting information through literature data, planning evaluation, developing draft modules, field testing to collect feedback, revising modules, improving modules for design and material improvements, then final module improvements for language and material improvements, and finally dissemination for module publication. The validation results indicated that the module achieved average scores of 94.22% from material experts and 94.10% from media experts, both categorized as excellent. The small-group and field trials obtained average percentages of 89.33% and 90.92%, respectively, also within the excellent category. Therefore, the PjBL-based ICT learning module is deemed feasible, engaging, and effective in enhancing vocational students' critical thinking and problem-solving skills.

A. INTRODUCTION

The Era of globalization and the Fourth Industrial Revolution requires vocational high school (SMK) graduates to master critical thinking and problem-solving skills. The modern workforce demands individuals who are not only technically skilled but also analytical, adaptive, and creative. This aligns with 21st-century learning emphasizing the 4C skills—Critical Thinking, Communication, Creativity, and Collaboration. Critical thinking helps students analyze information and make rational decisions, while problem-solving enables them to find effective solutions. Studies show that problem-based and project-based learning effectively develop these competencies. Adeline (2024) demonstrates that Project-Based Learning (PjBL) significantly improves learners' critical thinking and problem-solving abilities.

Project-Based Learning (PjBL) places students at the center of learning through authentic projects that link theory to practice, promote collaboration, and foster creativity. Through these projects, students are trained to connect theory with practice, collaborate effectively, and cultivate creativity. Puspitasari et al. (2020) found that PjBL modules enhance students' critical

thinking. Similarly, Stefany and Diana (2024) reported improved collaboration and communication skills, while Riak and Hananto (2023) noted increased autonomy and motivation. In science learning, Rahmadani et al. (2023) showed that PjBL strengthens the link between theory and practice, enhancing understanding and analysis.

Consequently, in line with the industrial revolution 4.0, the ICT curriculum in vocational schools continues to adapt to technological advancements, incorporating emerging topics such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data analytics (Hafizah, 2024). Observations and interviews at SMK Negeri 1 Tulungagung revealed challenges in applying PjBL to ICT learning, mainly due to the lack of integrated instructional modules. Existing materials remain traditional and less supportive of higher-order thinking, limiting students' understanding and practical skills. Thus, developing a PjBL-based ICT module is essential to enhance learning effectiveness and foster critical thinking and problem-solving in line with industry needs.

From a theoretical perspective, constructivist learning theory emphasizes that meaningful learning occurs when students actively construct knowledge through relevant experiences. In this context, a PjBL-based module functions not only as a self-instructional learning resource Mariu (2024) but also as a bridge between theory and practice. An effective learning module should be self-contained, stand-alone, adaptive, and user-friendly, allowing it to accommodate diverse learning needs (Magdalena et al., 2020).

According Ariadila et al. (2023) emphasized reflective learning for logical reasoning. Meanwhile, Sari et al. (2022) and Rachmatika (2024) found that problem-based learning enhances understanding and problem-solving. Collaborative learning also strengthens these skills along with social and communication abilities

This study found that implementing PjBL in the ICT module at SMK Negeri 1 Tulungagung faced challenges due to limited integrated teaching materials and weak application of multimedia design principles. As a result, it has not effectively enhanced students' critical thinking, problem-solving, and higher-order skills (Habibah, 2024)

The urgency for developing this module is underscored by a significant theory–practice gap observed in vocational ICT education. Field observations and interviews conducted at SMK Negeri 1 Tulungagung revealed that current ICT learning remains heavily traditional, relying on conventional materials that fail to integrate Project-Based Learning (PjBL) effectively. This lack of integrated instructional resources results in learning that is less supportive of higher-order thinking, ultimately limiting students' ability to apply theoretical concepts to practical, industry-relevant scenarios. Previous findings by Habibah (2024) confirm that a weak application of multimedia design principles and limited teaching materials have hindered the development of essential skills like critical thinking and problem-solving. Furthermore, while the curriculum demands mastery of 21st-century 4C skills, existing methods often fail to bridge the gap between classroom instruction and the complex demands of the digital workforce. Consequently, there is an immediate need for an innovative digital module that aligns computational thinking with authentic project activities to ensure graduates are not just technically skilled, but also analytical and adaptive.

Studies show that critical thinking and problem-solving are key competencies for vocational graduates, aligning with 21st-century 4C skills—Critical Thinking, Communication, Creativity, and Collaboration (Widiyanti et al., 2024). According to Hamsah et al. (2024), 65% of students felt that learning was less than optimal due to technological limitations. Another obstacle was the lack of adequate facilities and infrastructure needed by students to implement the independent learning curriculum, especially facilities and infrastructure such as online technology, laptops, and computers. Developing PjBL-based teaching modules enhances ICT learning effectiveness in vocational schools and aligns with workforce needs, as the PjBL approach effectively fosters critical thinking and problem-solving skills.

The primary research gap identified is the lack of integrated instructional modules that bridge the divide between theoretical ICT concepts and industry-standard practical application . Existing resources often focus on rote technical skills without fostering higher-order thinking or problem-solving. Furthermore, although previous studies have explored PjBL in general science or mathematics, there is a distinct lack of visually engaging digital modules that specifically align computational thinking with applied vocational topics like systems and networking. This study addresses this gap by developing a PjBL-based ICT module that serves as both a self-instructional resource and a bridge to real-world workplace scenarios, ensuring that vocational students can move beyond basic computer literacy to achieve complex analytical competence.

The novelty of the PjBL module lies in its ability to enhance self-directed learning, where students have greater control over their learning process so they are able to apply the knowledge in real learning and strengthen their competitiveness in the world of work, while the application of ICT can provide a more interactive and applicable learning experience, as well as improve students' technical competence in the field of technology (Yusuf et al., 2025).

The problem of this research is the lack of integrated learning modules and the continued use of traditional materials that fail to support higher-order thinking at SMK Negeri 1 Tulungagung. Furthermore, the application of technology to students is still weak, thus hampering the development of students' analytical and practical skills. Therefore, this research aims to determine the application of ICT and PjBL modules to improve critical thinking and problem-solving skills among vocational high school (SMK) students.

B. METHODS

1. Research and Development Procedures

This study utilizes the Research and Development (R&D) method with the Borg and Gall model, which consists of ten systematic stages to produce a learning product that is valid, practical, and effective. Each stage is described as follows:

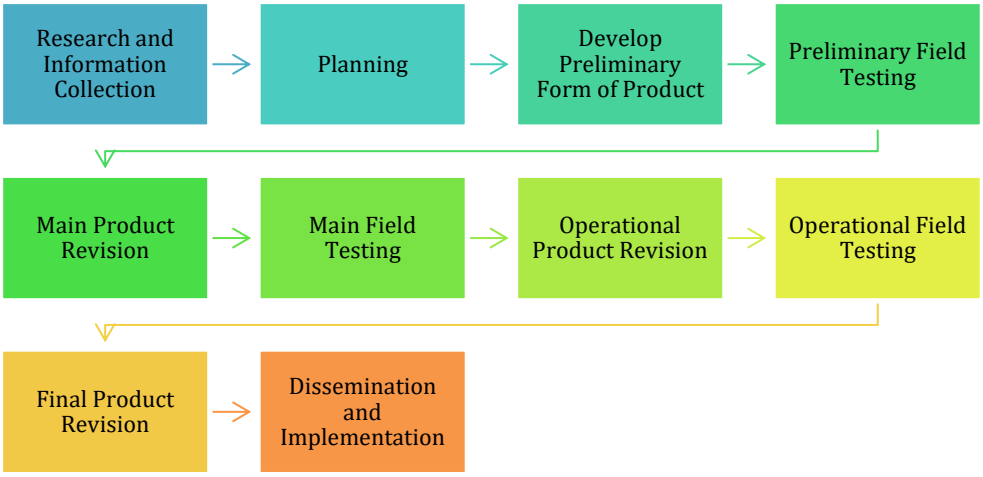


Figure 1. Research and Development Procedures

The process begins with Research and Information Gathering, where the need for a Problem-Job Learning (PjBL)-based module is identified through interviews and literature. During the Planning and Development phase, an initial draft is created featuring real-world projects and an assessment rubric. The module then undergoes rigorous Initial Field Testing through expert validation and small group pilot testing. After Main Product Revision, the module is tested in a larger Main Field Test involving 5 to 15 vocational high school students to assess critical thinking skills and student problem-solving abilities to assess the impact of using

the teaching module. After subsequent Operational Product Revision and further Operational Field Testing with more teachers, the Final Product Revision is completed. The cycle concludes with Dissemination, which involves workshops to train teachers on how to integrate the module into their classrooms.

2. Product Testing

The product testing stage evaluated the feasibility and effectiveness of the Project-Based Learning (PjBL) module in improving vocational students' critical thinking and problem-solving skills, using purposive sampling of ICT teachers, experts, and students.

The testing process included two stages: (1) expert validation and (2) field testing. Expert validation by an ICT teacher and a media design expert assessed the module's content, language, presentation, and visual design.

After validation, the module was tested in ICT classes with tenth-grade vocational students to evaluate its effectiveness in enhancing conceptual understanding, critical thinking, and problem-solving through project-based activities.

Data collection employed three instruments: questionnaires, observation, and documentation. The five-point Likert questionnaire gathered expert and student evaluations of module feasibility, observations tracked engagement and effectiveness, and documentation provided supporting evidence such as outcomes, activity logs, and visuals.

Table 1. Likert Scale Criteria

Score	Criteria
4	Strongly Agree
3	Agree
2	Somewhat Agree
1	Disagree

Source: Ernawati and Sukardiyono (2017)

3. Data Analysis

The data analysis process involved integrating information from multiple sources such as questionnaires, observations, and documentation to obtain valid and comprehensive findings. Observations were conducted to observe student engagement and the effectiveness of module use during the project-based learning process. A quantitative data analysis method was used to process the results of the validation questionnaires. The percentage of responses was calculated using the following formula:

$$P = \frac{\Sigma X}{\Sigma Xi}\ X\ 100\% \qquad (1)$$

Description:

P = Percentage of evaluation results from test subjects

ΣX = Total score obtained from test subjects

ΣXi = Maximum possible score from test subjects

The resulting percentages were then classified into categories to interpret the level of module feasibility. The classification criteria were adapted from Arikunto (2013) as shown below:

Table 2. Percentage Evaluation Criteria

No	Persentase	Keterangan
1	81-100%	Excellent
2	61-80%	Good
3	41-60%	Fair
4	21-40%	Poor
5	0-20%	Very Poor

Source: Arikunto (2013)

C. RESULT AND DISCUSSION

Based on the research and development conducted by Bagus Setiawan, the results can be explained module emphasized active student involvement through projects, discussions, and group activities to practice analysis and logic. Furthermore, during the initial field trial phase, through expert validation, the module was declared highly feasible, with an average assessment percentage of 94.22% from material experts covering content and language aspects, and 94.10% from media experts for cover design and attractive and proportional content. After undergoing revisions to the main product, a field trial was conducted involving 10th-grade students to measure the product's effectiveness. The small group trial yielded an average score of 89.33%, while the broader field trial yielded a score of 90.92%, both of which fall within the "Very Good" category. Based on this feedback, operational and final product revisions were conducted to refine the content and delivery methods before the module was finally ready for the dissemination and implementation phase.

1. Teaching Module Product

This research produced a Project-Based Learning (PjBL) teaching module for ICT subjects in vocational high schools, developed using the Borg and Gall R&D model and validated for feasibility and pedagogical effectiveness. The development process consisted of three main stages:

a. Need Analysis

Observations at SMK Negeri 1 Tulungagung show that ICT materials are still traditional, lack contextual relevance, and have not integrated PjBL to develop critical thinking and problem-solving skills. This condition demands updating the materials to be more practice-oriented. The urgency of PjBL integration is supported by strong empirical evidence in a meta-analysis conducted by Zhang et al. (2024). The study reported that PjBL has a positive impact at the moderate-to-large level on improving critical thinking and problem-solving, while also proving that PjBL is an effective instrument to bridge the gap between theory and practice in engineering education.

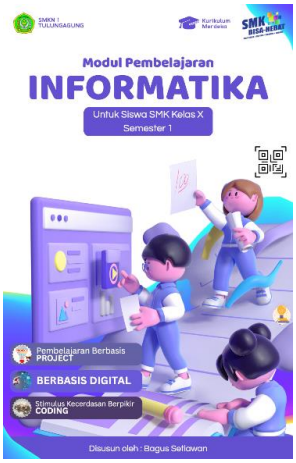
b. Design of Learning Materials

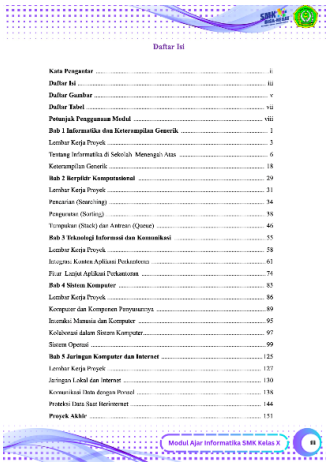
The module covered 19 instructional hours across five chapters Informatics and Generic Skills, Computational Thinking, ICT, Computer Systems, and Computer Networks plus evaluations. Each chapter included project-based activities, assessment rubrics, and self-instructional guidance. The material design integrates computational thinking concepts with applied ICT topics, aligning with research recommending their combination to help students transfer problem-solving skills across domains. Saad et al. (2022) found that PjBL significantly enhances computational thinking, critical thinking, and problem-solving skills, thereby providing a strong theoretical basis for this module's design.

Recent studies highlight that process rubrics and self-instructional components enhance metacognitive skills and module practicality. Thus, incorporating rubrics, reflection, and project activities in this ICT module reinforces PjBL principles and instructional effectiveness (Fadhilah & Thahir, 2023).

c. Module Development

The final product is an interactive ICT Learning Module for Grade X Vocational Students (Semester 1) using the Project-Based Learning approach. Developed as an interactive PDF, it supports flexible, technology-enhanced learning. The modern cover and organized table of contents reflect the module's innovative, structured design, as shown in Figures 1 and 2.





Figures (1) and (2) respectively display the cover and table of contents of the PjBL-based teaching module

Each chapter includes project worksheets that apply theory to real-world contexts. For example, in Chapter 3, "Information and Communication Technology," students create integrated office application projects simulating industry practices, fostering critical thinking, collaboration, and problem-solving skills.

According to Lika et al. (2024) Implementing digital modules developed through a Project-Based Learning (PjBL) framework significantly enhances critical thinking and problem-solving, as students engage in exploration and product creation reflecting real workplace scenarios. The project-oriented design also promotes self-reflection, increasing learners' awareness of their learning processes and outcomes.

According to research by Mariya et al. (2024), implementing a digital module based on PjBL can improve critical thinking and problem-solving skills because students are directly involved in the exploration and creation of products relevant to the world of work. Modules developed with a project orientation also provide space for students to self-reflect on their learning process and outcomes.

2. Module Feasibility Test

Feasibility testing is conducted after the initial product is developed. According to the Borg & Gall development model, the testing phase consists of three stages: validation by experts (subject matter experts and media experts), limited or small-group trials, and field or large-group trials.

a. Content Expert Validation

After the PjBL module prototype was completed, expert validation was conducted by content and media experts to assess content, presentation, language, and visual design. Two content validators evaluated three aspects—content feasibility, presentation, and language—as summarized in Table 1.

Tabel 3. Summary of Content Expert Validation Results

No	Assessment Aspect	ΣX (Expert 1 + Expert 2)	ΣXT (Total)	P(%) Average	Criteria
1	Content	76 + 74 = 150	160	(95 + 92,5)/2 = 93,75	Excellent
2	Presentation	46 + 44 = 90	96	(95,8 + 91,67)/2 = 93,74	Excellent
3	Language	49 + 50 = 99	104	(94,2 + 96,15)/2 = 95,18	Excellent
	Total	**339**	**360**	**(95 + 93,44)/2 = 94,22**	**Excellent**

Based on the overall results of the expert validation aspect scores in Table 3, the results of the expert validation results are depicted in Figure 3

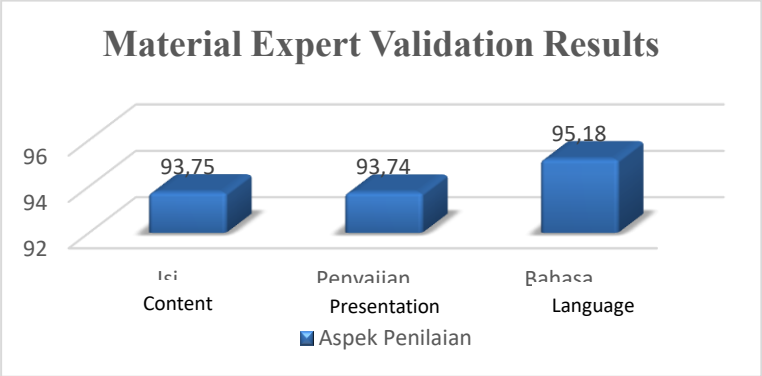


Figure 3. Overall Validation Results of Material Experts

Material expert validation showed an average score of 94.22% (very good) for content, presentation, and language, indicating the module's strong academic quality and clarity. These results align with Taib et al. (2025) and Selvia et al. (2023), who reported similarly high validity in PjBL and e-module studies, confirming the module's readiness for field testing without major revisions.

b. Media Validation

In the media validation process, two main aspects were evaluated: cover design and content design. These aspects were broken down into 29 statement items used as assessment indicators. The recapitulation of validation results from the two media experts is presented in Table 4.

Table 4. Summary of Media Expert Validation Results

No	Assessment Aspect	ΣX (Expert 1 + Expert 2)	ΣXT (Total)	P(%) Average	Criteria
1	Desain Sampul	34 + 34 = 68	72	(94,44 + 94,44)/2 = 94,44	Excellent
2	Desain Isi	74 + 76 = 150	160	(92,5 + 95)/2 = 93,75	Excellent
	Total	**222**	**232**	**(93,47 + 94,72)/2 = 94,10**	**Excellent**

Based on the overall results of the expert validation aspect scores in Table 2, the results of the expert validation results are shown in Figure 4.

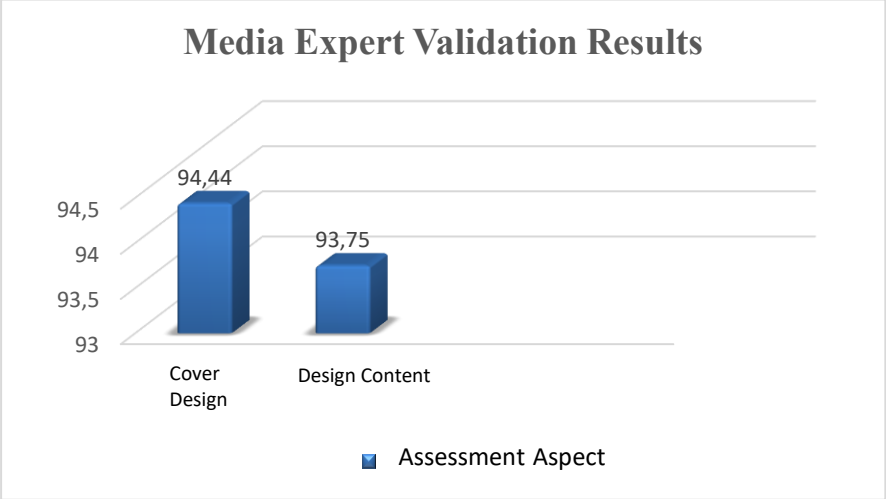


Figure 4. Overall Validation Results of Media Experts

Studies in vocational education R&D show that e-modules with high media validation typically gain positive student feedback and are practical for classroom use. Thus, the 94.10% validation score in this study confirms the module's strong media feasibility. Its visual design enhances motivation and focus by supporting easy navigation and reducing cognitive load (Stoesz & Niknam, 2022). This finding aligns with studies showing that effective visual design enhances knowledge retention and understanding, especially when paired with authentic projects (Aisyah et al., 2023 ; Resmanti et al., 2024). The high media validation score thus supports the module's readiness for implementation.

When integrated with pedagogical features such as project scaffolding, rubrics, and reflection sheets, these elements enhance critical thinking and problem-solving. Meta-analyses further confirm that strong instructional design and media quality significantly boost PjBL's impact on higher-order thinking skills (Zhang & Ma, 2023 ; Zhang et al., 2024).

c. Small Group Trial

A limited trial with 10 tenth-grade students at SMK Negeri 1 Tulungagung yielded a very good overall score of 89.33%. Visual appearance (92.50%), material presentation (87.14%), and usefulness (90.50%) all rated high. These results align with findings by Mangesa et al. (2024) and Mardalena and Nelmira (2024), confirming strong validity and practicality. Although presentation scored slightly lower, minor refinements to project instructions could further improve clarity before large-scale implementation.

d. Field Trial

The field trial with 36 tenth-grade students at SMK Negeri 1 Tulungagung showed an average score of 90.92% (very good) across visual design, material presentation, and usefulness. The visual aspect (94.21%) proved crucial for engagement, supporting Afwa et al. (2023), who found that strong visual design enhances learning effectiveness. Material presentation (88.79%) met pedagogical standards, aligning with Nurhamida and Andromeda (2023), who emphasized contextual and coherent content for better understanding. The usefulness aspect (91.94%) indicated that students found the module highly beneficial for independent, collaborative, and contextual learning, consistent with Wulandari et al. (2025) and Zhang & Ma (2023). Overall, the trial confirmed that integrating PjBL in ICT modules effectively develops students' higher-order thinking, critical thinking, and problem-solving through experiential, project-based learning

D. CONCLUSION AND SUGGESTIONS

The analysis shows that ICT learning at SMK Negeri 1 Tulungagung still faces challenges due to the lack of comprehensive and relevant learning modules. To address this, a 19-hour Project-Based Learning (PjBL) module was developed covering informatics, computational thinking, ICT, computer systems, and networking, with each chapter designed to foster analysis, discussion, and collaboration. Validation results showed high feasibility, with material experts rating the module 94.22% and media experts 94.10%, confirming its strong content quality and visual design. Small-group and field trials scored 89.33% and 90.92%, indicating the module's effectiveness and positive reception among students.

Recommendations for future research include encouraging students to express their ideas, discuss them, and collaborate to generate creative solutions. Furthermore, for principals in future research, researchers need to create policies that encourage the integration of teaching modules into digital-based learning systems (e-learning/LMS). Furthermore, for teachers in future research, researchers need to integrate the use of modules with other learning media (e.g., digital simulations, LMS, or practical applications).

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