

Integrated Project-Problem Learning (IPPL) to Promote the Programming Skills of Vocational Students

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ABSTRACT: *The objectives of this research were as follows: (1) synthesize an Integrated Project-Problem Learning (IPPL) to enhance the programming skills of vocational students; (2) develop the proposed learning process; and (3) evaluate its appropriateness. The instructional design was based on an integration of Project-Based Learning (PjBL) and Problem-Based Learning (PBL), structured into three main components: input factors, learning process, and outcomes. The development process led to the formation of the IPPL for Vocational Programming Skills model, comprising five instructional steps: problem analysis, solution design, project implementation, testing and refinement, and presentation with reflection. These steps promote analytical thinking and the development of systematic programming skills.*

The evaluation of the IPPL process by subject-matter experts indicated that the overall appropriateness was rated at the highest level in terms of the conceptual framework, the process design, the learning activities, and the feasibility for classroom implementation, particularly in programming-related courses. Therefore, it can be concluded that the IPPL for Vocational Programming Skills model is a pedagogical approach that can be effectively applied in vocational education to enhance learners' programming competencies in a structured and meaningful way.

Keywords: Integrated Project-Problem Learning, Project-Based Learning, Problem-Based Learning, Programming Skills, Vocational Education

1. Introduction

The 2024 Vocational Certificate Curriculum is based on the principle of providing and advancing vocational education in such a way as to elevate individuals' competencies, and provide them with professional qualifications, with an emphasis on practice-based learning in order to develop skilled workforce competencies and aims to cultivate learners who demonstrate personal behaviors and actions that reflect appropriate personality traits, character, values, professional ethics, attitudes, and positive learning habits together with a knowledge of facts, principles, theories, and practices related to their field of study or profession. It means that they will be able to work according to a pre-conceived plan, adapt to changes that are not complicated, and be aware of and participate in solving economic, social, political, and environmental problems (Vocational Certificate Curriculum, 2024).

In the core competency section of the Industrial Program under the 2024 Vocational Certificate Curriculum, the occupational group of energy, electrical, and electronics—specifically the Electronics program—includes the subject Computer Programming as one of the specialized vocational competency courses. This subject aims to develop learners' occupational competencies in alignment with industry demands and in accordance with the Professional Qualification Standards and the National Skill Standards. The course emphasizes the effective application of knowledge relating to information technology and programming (Vocational Certificate Curriculum, 2024). Computer programming is regarded as a fundamental course for vocational certificate students in the field of electronics. It focuses on enabling students to learn and practice programming using C language or other relevant programming languages, along with analyzing and designing systems, subprograms, and functions. The course is designed to equip

students with essential skills for further study or for engaging in careers in the field of information technology in the future.

Project-Based Learning (PjBL) is an instructional approach that encourages learners to engage in the development of projects based on real-world problems. This method emphasizes hands-on experience, data analysis, and the systematic development of ideas. Such learning fosters essential skills such as teamwork, planning, and project management—skills that are highly relevant and critical in the fields of software engineering and technology development (Rupavijetra et al., 2022).

Based on the identified problems and significance, the researchers designed an integrated project- and problem-based learning process to enhance programming skills for vocational students. This instructional approach aims to address the issues by enabling students to think analytically, solve problems, and systematically develop projects through hands-on practice and real-world learning experiences. The process supports the development of programming competence and helps prepare learners for future careers in the technology and industrial sectors.

2. Research Objectives

2.1 To synthesize an integrated project- and problem-based learning process to enhance programming skills on the part of vocational students.

2.2 To develop the integrated project- and problem-based learning process to enhance programming skills on the part of vocational students.

2.3 To evaluate the appropriateness of the integrated project- and problem-based learning process in enhancing programming skills on the part of vocational students.

3. Research Methodology

This research involves the development of an integrated project- and problem-based learning process aimed at enhancing programming skills on the part of vocational students. The research was conducted using the following methodology

1. The participants in the research were 5 experts from vocational education institutions with knowledge, skills and experience in teaching management for at least 5 years.

2. Research Instruments and Statistical Analysis. In developing the IPPL process to enhance programming skills for vocational students, the research team employed the following instruments and statistical methods (1) The IPPL for Vocational Programming Skills learning process developed as part of this study, and (2) an evaluation form to assess the appropriateness of the IPPL learning process. The data obtained from the evaluation were analyzed using measures of mean (M) and standard deviation (SD) to determine the level of appropriateness of the developed instructional process.

3. Research Procedures. The research team designed and developed the learning process based on the theoretical foundation of systems-based instructional design (Khemmani, 2010). The process was divided into three main phases as illustrated in Figure 1.

Step 1: Literature Review and Conceptual Framework Development. In this phase, the researchers studied, analyzed, and synthesized relevant documents and research related to the IPPL for Vocational Programming Skills. The findings were used to establish the conceptual framework for the study. The review focused on four key areas: (1) the Vocational Certificate Curriculum, (2) Project-Based Learning (PjBL), (3) Problem-Based Learning (PBL), and (4) Programming Skills.

Step 2: Development of the IPPL process to enhance programming skills on the part of vocational students. In this phase, the researchers developed the IPPL for Vocational Programming Skills by integrating key concepts from Project-Based Learning (Rupavijetra et al., 2022) and Problem-Based Learning (Kanoknitanunt et al., 2021). The resulting instructional model consists of three main components (1) Input Factors, (2) Learning Process, and (3) Learning Outcomes.

Step 3: Evaluation of the IPPL process to enhance programming skills on the part of vocational students. In this phase, the researchers conducted an evaluation of the developed IPPL for

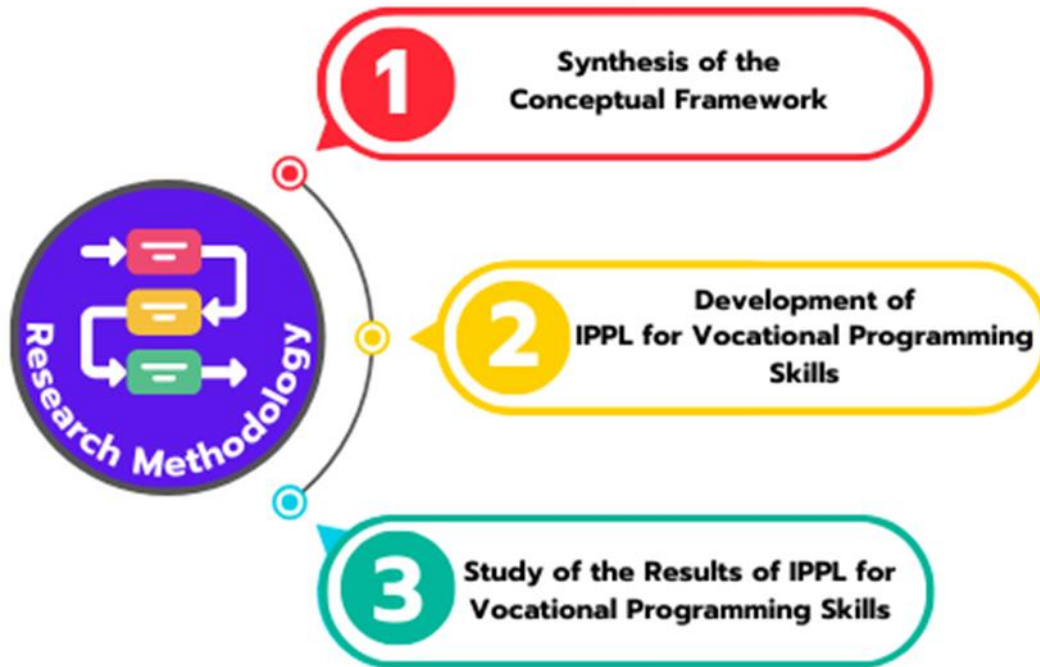


Figure 1 Research Methodology

Vocational Programming Skills using research instruments applied to a group of purposively selected participants. The participants consisted of 5 experts with more than five years knowledge and experience in vocational education instruction. The evaluation was conducted based on assessment criteria and interpretation guidelines adapted from Kanasutra (1995), as presented in Table 4:

Table 4. Mean score range and interpretation of results

Range of average score	Interpretation of suitability
4.50 – 5.00	Highest
3.50 – 4.49	High
2.50 – 3.49	Moderate
1.50 – 2.49	Low
0.00 – 1.49	Lowest

4. Result

From the study, analysis, and synthesis of documents and research related to the development of the IPPL process to enhance programming skills on the part of vocational students, the results are summarized as follows

4.1 Results of the theoretical synthesis related to the IPPL process to enhance programming skills on the part of vocational students.

From Table 1, we can see that the results of the synthesis of the project-based learning process are divided into 5 steps. These are as follows: 1) Preparation: The teacher formulates a learning management plan based on the curriculum objectives and conducts an orientation session to help students understand the principles of project-based learning. During this stage, the teacher provides guidance and suggestions, while students engage in research, form working groups, brainstorm ideas, explore project feasibility, identify core problems, and prepare a preliminary project plan. 2) Topic Definition: The teacher approves the proposed project topics and provides suggestions for improvement. Throughout this stage, the teacher monitors the learning process and offers ongoing guidance. Students develop detailed project plans, present their project topics, receive feedback, and revise their plans accordingly.

3) Implementation: The teacher supervises and monitors the students' progress, listens to problems, and provides constructive feedback.

Table 1 The Synthesis of the Project-Based Learning Process

Synthesis of Project-Based Learning Process	(Rupavijetra et al., 2022)	(Chatwattana & Nilsook, 2017)	(Sisamud, 2022)	(Wongkumsin & Singhwee, 2020)	(Maowtub, 2020)	(Visuttakul, 2021)	(Chang et al., 2024)	(Pan et al., 2018)	Selected
Preparation	✓	✓	✓	✓					✓
Planning					✓	✓	✓	✓	
Topic Definition	✓	✓	✓	✓	✓	✓	✓	✓	✓
Project Proposal Development		✓		✓					
Implementation	✓			✓	✓	✓	✓	✓	✓
Construction and Testing			✓						
Report Writing					✓				
Presentation	✓	✓	✓	✓	✓		✓	✓	✓
Evaluation	✓	✓	✓	✓		✓	✓	✓	✓

Students proceed with creating their project artifacts, conduct testing, and make necessary modifications to resolve any issues encountered during development. (4) Presentation: The teacher listens to student presentations, provides encouragement, constructive feedback, and supports the project outcomes. Students present their work, receive suggestions, and revise their projects in order to enhance quality and clarity (5) Evaluation: The teacher assesses the project based on authentic, real-world performance criteria and collaborates with experts to ensure a comprehensive evaluation. Additionally, students participate in self-assessment and peer assessment to reflect on their individual performance and contributions within the team.

Problem-Based Learning (PBL) is an instructional approach that enables learners to practice problem-solving skills by starting with problem identification, followed by analysis and information gathering to determine appropriate solutions. This process fosters the development of systems thinking, hypothesis formulation, and the testing of possible solutions (Kanoknitanunt et al., 2021)

From Table 2 we can see that the results of the synthesis of the problem-based learning process are divided into 6 steps as follows: (1) Problem Identification: This is the initial step that focuses on recognizing and defining the problem or topic to be studied. In this stage, learners are required to analyze the context and determine the scope of the problem clearly. This process helps develop analytical thinking and effective questioning skills. (2) Understanding the Problem: In this stage, learners study the fundamentals of the problem, understand its context, and identify relevant factors. This may involve brainstorming, formulating hypotheses, or analyzing the root causes of the problem. The process enhances learners' systems thinking skills and promotes deeper comprehension of the issue under consideration. (3) Research and Data Collection: Learners begin gathering information from various sources such as documents, research articles, interviews, or field surveys. The collected data serves as the foundation for problem-solving. This stage helps develop research skills, questioning techniques, and the ability to evaluate and filter relevant information effectively. (4) Knowledge Synthesis: This stage involves analyzing and synthesizing the collected information to develop problem-solving approaches or generate new ideas. Learners may engage in discussion, create concept maps, or conduct experiments to test hypotheses. This process fosters critical thinking and innovation skills. (5) Conclusion & Evaluation: In this stage, learners analyze the outcomes of the proposed solutions, evaluate the strengths and weaknesses of each approach, and consider their appropriateness. This process enhances learners' skills in terms of evaluation, decision-making, and improving the effectiveness of solutions. (6) Presentation & Performance

Evaluation: This final stage requires learners to present their solutions or project outcomes to a target audience in order to receive feedback and make necessary improvements. Additionally, learners reflect on and evaluate their own learning process to enhance future performance. This stage strengthens skills in communication, presentation, and learning from mistakes.

Table 2 The Synthesis of Problem-Based Learning Process

Synthesis of Problem-Based Learning Process	(Rattanakha & Chatwattana, 2023)	(Kanoknitanunt et al., 2021)	(Duangsongd, 2022)	(Namkote, 2023)	(Sudjimat et al., (2021)	(Chaiwong, 2021)	(Sutarto et al., 2022)	(Yew & Goh, 2016)	Selected
Problem Identification	✓	✓	✓	✓	✓	✓	✓	✓	✓
Understanding the Problem	✓	✓	✓	✓	✓	✓	✓	✓	✓
Research and Data Collection	✓	✓	✓	✓	✓	✓	✓	✓	✓
Knowledge Synthesis	✓	✓	✓	✓	✓	✓	✓	✓	✓
Conclusion & Evaluation	✓	✓	✓	✓	✓	✓	✓	✓	✓
Presentation and Performance Evaluation	✓	✓	✓	✓	✓	✓	✓	✓	✓

Programming skills refers to the ability to design and construct a set of instructions that enable a computer to perform tasks according to specified goals. This encompasses understanding the problem, applying logical thinking, designing algorithms, utilizing programming language syntax, debugging, and improving program efficiency (Xie et al., 2019).

Table 3 The Synthesis of Programming Skills

Synthesis of Programming Skills	(Lertyosbordin et al., 2022)	(Punjansing & Sae-Joo, 2019)	(Skalka et al., (2021)	(Alghamdi, (2025)	(Hongyai, 2022)	(Xie et al., 2019)	(Duris et al., 2022)	(Liao, 2020)	Selected
Problem Analysis	✓	✓	✓	✓	✓	✓	✓	✓	✓
Program Design	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coding & Implementation	✓	✓	✓	✓	✓	✓	✓	✓	✓
Testing & Debugging	✓	✓	✓	✓	✓	✓	✓	✓	✓
Presentation	✓		✓		✓	✓		✓	✓

From Table 3, we can see that the study of programming skills mean the ability to develop programs. This process consists of 5 steps as follows:

1. Problem Analysis: This is the initial stage in which the developer must understand the problem or system requirements, analyze the project scope, and define the features of the program to be developed. This stage may involve user interviews, data analysis, and the specification of system requirements.

2. Program Design: This stage involves transforming the analyzed problem data into a clear program structure. Tools such as flowcharts and pseudocodes are used to define the logical sequence of operations within the program, ensuring that the design aligns with the system's objectives and functions effectively.
3. Coding & Implementation: At this stage, the program design is translated into actual code using an appropriate programming language such as C, Python, Java, or others, depending on the system requirements. Developers focus on writing efficient and maintainable code based on the design specifications.
4. Testing & Debugging: Once coding is complete, the program undergoes rigorous testing to identify and resolve any errors or bugs. The objective is to verify that the program operates correctly and meets the intended functionality as defined in the design phase.
5. Presentation: The final stage involves presenting the program's functionality, typically through user documentation and demonstration. This helps ensure the program is understandable, usable, and ready for further maintenance or future enhancement.

From the study, analysis, and synthesis of the relevant literature and research related to the development of the IPPL for Vocational Programming Skills, the following key theoretical components were identified and used to establish the conceptual framework of the study: the Vocational Certificate Curriculum, Project-Based Learning (PjBL), Problem-Based Learning (PBL), and Programming Skills. These components are illustrated in Figure 2.

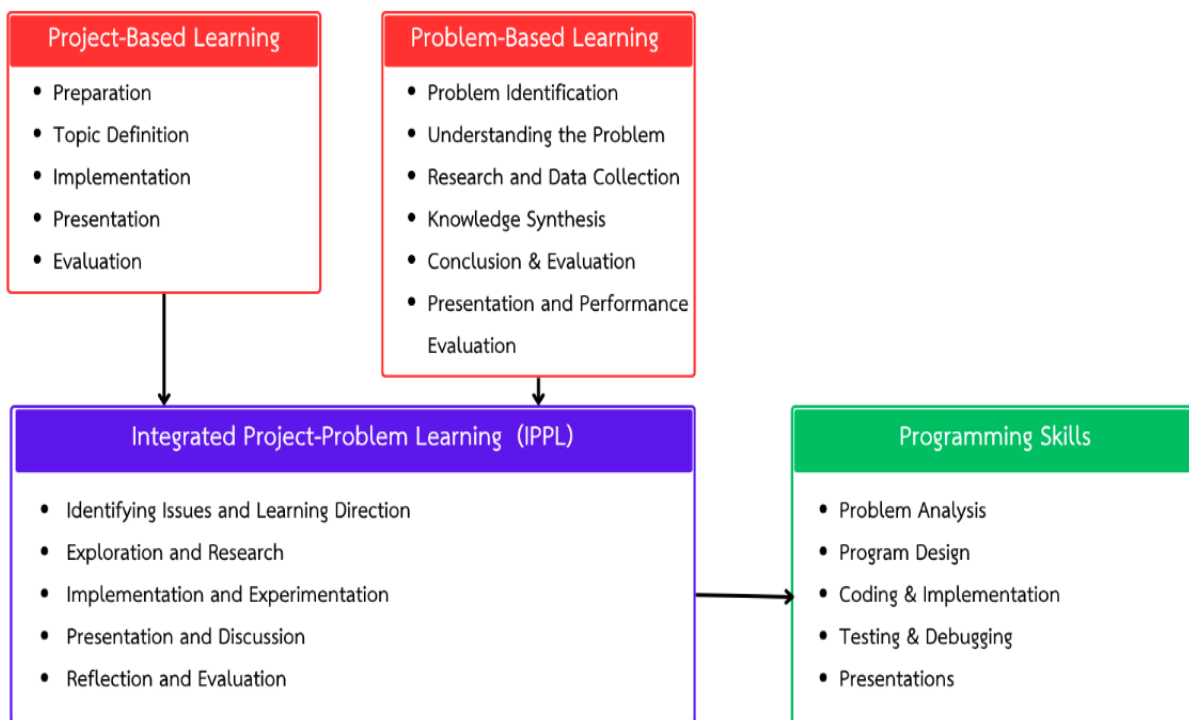


Figure 2 Conceptual Framework of the Study

4.2 Results of the development of the IPPL process to enhance programming skills on the part of vocational students. To serve as a guideline for instructional management aimed at enhancing programming skills, this study developed an instructional process by integrating the principles of Project-Based Learning (PjBL) and Problem-Based Learning (PBL). The resulting IPPL process encourages learners to engage in hands-on activities through project development, with problem contexts as the central focus. The instructional design was based on a systems approach and consists of three main components: Input Factors, Learning Process, and Learning Outcomes.

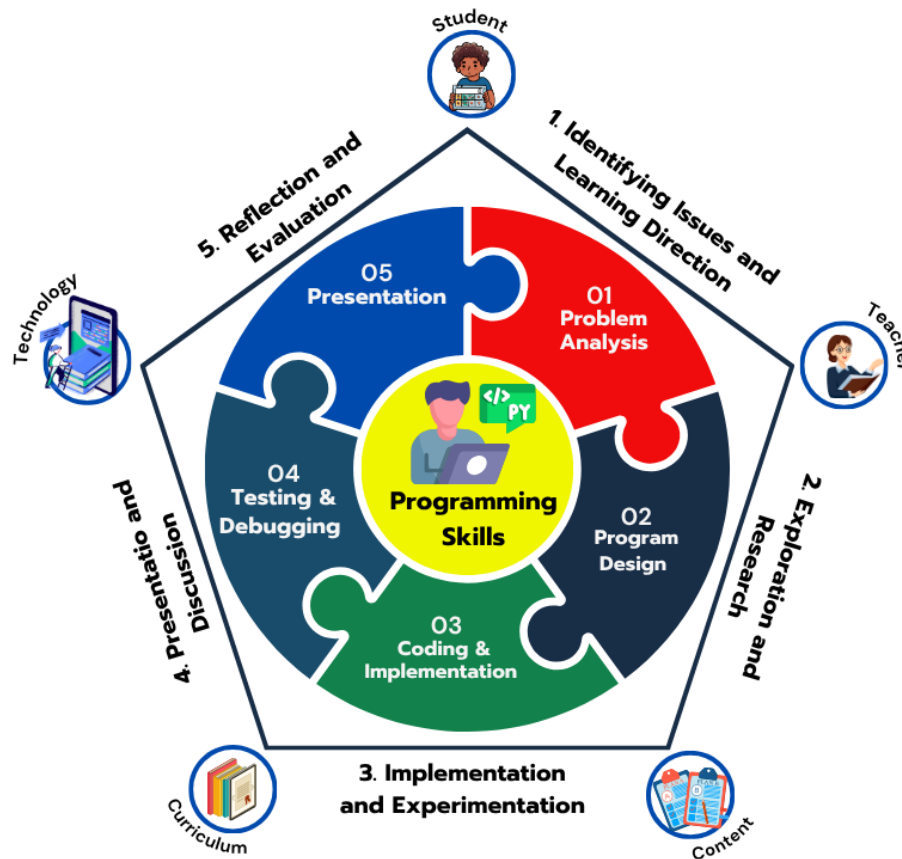


Figure 3 IPPL for Vocational Programming Skills Model

From *Figure 3* we can see that the IPPL for Vocational Programming Skills has 3 components. These are as follows

1. Input Factors. The input factors in IPPL for Vocational Programming consist of key components that influence the effectiveness of teaching and learning. These take the form of students, teachers, course content, curriculum, and technology.

- 1.1 Students. Students are the individuals participating in the learning process. In the context of this study, they are vocational students enrolled in a computer programming course, learning programming skills through a process that integrates the power of both artificial intelligence (AI) and human engagement.

- 1.2 Teachers. Teachers are responsible for delivering knowledge, providing guidance, and designing learning experiences. In this model, the teacher facilitates learning by integrating AI and human collaboration through the use of anticipatory concept maps to foster programming skills.

- 1.3 Content. Course content refers to the instructional material that includes foundational programming knowledge such as data structures, algorithms, and programming design principles. It also encompasses concepts related to problem-solving and project development. The content ranges from basic to complex and emphasizes real-world project implementation to enhance learners' analytical thinking, program design skills, and teamwork skills within industry-relevant contexts.

- 1.4 Curriculum. The curriculum refers to the Vocational Certificate Curriculum 2024, which is designed to promote hands-on, competency-based learning. It aims to enhance learners' professional skills, and encourage critical thinking and adaptability by aligning instructional content with labor market demands and national skill standards. The curriculum encourages learners to engage in real-world problem-solving through project-based learning, integrating both theoretical and practical knowledge.

- 1.5 Technology. Technology encompasses the digital tools and platforms used to support learning activities, including programming environments, simulation software, and AI systems. In this research context, technology plays a central role in facilitating the learning process by enabling students to code, test, and develop solutions in realistic

scenarios. It also supports interaction between learners and AI through the use of tools such as Replit, ChatGPT, and Gemini, helping to enhance programming skills through collaborative and guided learning.

2. Learning Process. The learning process was synthesized by integrating PjBL with PBL, resulting in a new instructional model comprising five stages:

Step 1: Identifying issues and learning direction. The process begins with identifying a relevant problem or project topic. Learners conduct preliminary research to understand the scope, set objectives, and create a systematic work plan. This stage enhances analytical thinking and strategic planning skills.

Step 2: Exploration and research. Learners search for information from various sources including research articles, books, online resources, or expert interviews. They analyze the collected data and synthesize potential solutions, which helps develop skills in research, questioning, and information evaluation.

Step 3: Implementation and experimentation. After identifying solutions or completing the project plan, learners proceed to test, refine, and develop their proposed solutions or construct the actual project artifacts. This stage promotes teamwork, hands-on skills, and systematic problem-solving.

Step 4: Presentation and discussion. Upon completion of the project or arriving at a problem solution, learners present their results to peers, instructors, or experts to receive feedback and insights. This stage fosters communication, critical thinking, and iterative improvement based on constructive suggestions.

Step 5: Reflection and evaluation. In the final stage, learners reflect on the outcomes, assess the project's success, and analyze the strengths and weaknesses of the process. This reflection helps develop learning-from-experience skills, self-improvement, and planning for future enhancement.

3. Learning Outcomes. That is, programming skills refer to the ability to design, develop, and modify computer programs using various programming languages. This procedure consists of 5 steps: (1) Problem Analysis (2) Program Design (3) Coding & Implementation (4) Testing & Debugging (5) Presentation.

4.3 Evaluation results of the suitability of IPPL for Vocational Programming to enhance programming skills on the part of vocational students. The skills from the study of the results of the development of the PjBL process combined with problem-solving to promote programming skills on the part of vocational students were evaluated by 5 specifically selected participants who were experts in vocational educational institutions with 5 years or more knowledge, skills, and experience in teaching management. The process is as shown in Tables 5, 6 and 7.

Table 5 Results of the evaluation of the suitability of the IPPL process for developing Vocational Programming Skills (Overall components)

Evaluation list	Evaluation results		Interpretation
	Mean	SD.	
1.To what extent are the principles and concepts used as the foundation for developing IPPL for vocational programming skills appropriate as a whole	4.80	0.40	Highest
2. To what extent are the components of IPPL for vocational programming skills appropriate, considering the comprehensiveness of key elements in a general learning process?			
2.1 Input Factors	4.75	0.43	Highest
2.2 Learning Process	4.60	0.49	Highest
2.3 Learning Outcomes	4.60	0.49	Highest
Overall	4.69	0.45	Highest

From Table 5, we can see that in terms of the evaluation of the overall appropriateness of the IPPL process for Vocational Programming indicated that the model was rated at the highest level of appropriateness (Mean = 4.69, SD. = 0.45). It can therefore be concluded that the IPPL process incorporates complete and essential components and

is suitable for use as a practical guideline for developing instructional models that integrate project-based and problem-based learning to enhance programming skills on the part of vocational students.

Table 6 Results of the evaluation of the suitability of the IPPL process for developing Vocational Programming Skills (Overall components)

Evaluation list	Evaluation results		Interpretation
	Mean	SD.	
1. What level of appropriateness is the developed IPPL for Vocational Programming Skills for use in learning management.	4.80	0.40	Highest
2. What is the level of appropriateness of the developed IPPL model for enhancing vocational programming skills in terms of its development steps and instructional processes	4.40	0.49	High
3. Overview of the developed IPPL for Vocational Programming Skills. To what extent is it possible for such skills to be tested	4.80	0.40	Highest
Overall	4.67	0.43	Highest

From Table 6 we can see that the evaluation of the overall appropriateness of the IPPL for Vocational Programming Skills indicates that the model was rated at the highest level (Mean = 4.67, SD. = 0.43). This suggests that the IPPL for Vocational Programming Skills incorporates complete and essential components and can be effectively used as a guideline for instructional management.

Table 7 Results of the assessment of the suitability of the IPPL process for Vocational Programming Skills development

Evaluation list	Evaluation results		Interpretation
	Mean	SD.	
1. Input Factors			
1.1 Students	4.60	0.80	Highest
1.2 Teachers	4.40	0.80	High
1.3 Content	4.80	0.40	Highest
1.4 Curriculum	4.60	0.49	Highest
1.5 Technology	4.60	0.49	Highest
2. Learning Process			
2.1 Identifying Issues and Learning Direction	4.60	0.49	Highest
2.2 Exploration and Research	4.80	0.40	Highest
2.3 Implementation and Experimentation	5.00	0.00	Highest
2.4 Presentation and Discussion	4.80	0.40	Highest
2.5 Reflection and Evaluation	4.80	0.40	Highest
3. Learning Outcomes			
3.1 IPPL for Vocational Programming Skills			
3.1.1 Problem Analysis	4.80	0.40	Highest
3.1.2 Program Design	4.80	0.40	Highest
3.1.3 Coding & Implementation	4.60	0.49	Highest
3.1.4 Testing & Debugging	4.60	0.49	Highest
3.1.5 Presentation	4.20	0.40	High
Overall	4.67	0.46	Highest

From Table 7, the evaluation of the appropriateness of the IPPL process for the development of Vocational Programming Skills revealed that the overall suitability was rated at the highest level (Mean = 4.67, SD. = 0.46). When considering the specific components, the results show that the Input Factors, Learning Process, and Learning Outcomes were all rated at the highest level. Notably, the Learning Outcomes were assessed in detail across five key skills: Problem Analysis, Program Design, Coding & Implementation, Testing & Debugging, and Presentation, all of which demonstrated high to highest suitability. It can be concluded that the IPPL process incorporates complete and well-structured components, making it a viable framework for designing integrated project- and problem-based learning processes aimed at enhancing programming skills for vocational students.

5. Discussion

5.1 The results regarding the development of IPPL process for enhancing programming skills on the part of vocational students revealed that the integration of PjBL and PBL led to the creation of a new, systematic instructional model aligned with the context of 21st-century learning. The developed process consists of five key stages (1) Problem Analysis, (2) Designing Solutions, (3) Project Implementation, (4) Testing and Refinement, and (5) Presentation and Reflection. Each stage was designed to correspond with the sequential logic of the programming development process, while simultaneously fostering critical thinking, creativity, collaboration, and experiential learning. These findings align with the perspective of Xie et al. (2019), who emphasize that programming instruction should integrate both problem-solving and hands-on practice to effectively prepare students to meet the challenges of the digital age.

5.2 The evaluation of the IPPL process for Vocational Programming Skills by experts indicated that the overall appropriateness was rated at the highest level across all aspects—including its principles, conceptual foundation, structure, and feasibility for practical implementation. These results reflect the completeness and effectiveness of the learning process, which successfully integrates educational theory with real-world learning applications. This is particularly relevant to programming courses, which require both technical skills and systematic thinking. The findings are consistent with the findings of the study by Punjansing and Sae-Joo (2019), which emphasized that combining project-based and problem-based learning significantly enhances learners' analytical thinking, content comprehension, and ability to flexibly apply knowledge in new contexts—skills that are essential in vocational education. Moreover, the IPPL model fosters meaningful learning and promotes active student engagement, which are fundamental to effective learning in the modern era (Xie et al., 2019; Punjansing & Sae-Joo, 2019).

6. Conclusion

This research successfully synthesized and developed the Integrated Project-Problem Learning (IPPL) process, resulting in a comprehensive instructional model comprising five key steps: Identifying Issues, Exploration, Implementation, Presentation, and Reflection. The evaluation by experts confirmed that the developed IPPL for Vocational Programming Skills is highly appropriate for instruction, effectively bridging the gap between theoretical understanding and practical application. The model represents a promising instructional approach that can be effectively applied in vocational programming education. To ensure optimal implementation outcomes, it is recommended that institutions intending to adopt this model adapt it to align with their specific curricular contexts, available learning resources, learners' foundational skills, as well as personnel and technological capacities. Furthermore, regarding future research directions, pilot implementation and field-based testing are crucial mechanisms to empirically validate the model's effectiveness in practice. Future studies should focus on applying this model in actual classrooms to assess real-world learning outcomes. These efforts will support the model's scalability and sustainability, enabling its broader adoption in educational policy and vocational training systems at an institutional or national level.

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