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Development and Effectiveness of an Interactive Prompt Engineering E-Module to Enhance Vocational Students' Learning Outcomes

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ABSTRACT

This study aimed to develop and evaluate an interactive e-module on Prompt Engineering to support the use of generative AI in learning for vocational students. The research employed a 4-D (Define, Design, Develop, Disseminate) Research and Development model and a one-group pretest–posttest design, the study involved 113 students in self-directed learning. Data were analyzed using the Wilcoxon Signed-Rank test. Results indicated a significant difference between pretest and posttest scores (pretest: $M = 67.52$, $SD = 6.09$; posttest: $M = 81.06$, $SD = 5.41$; $\Delta M = 13.54$) ($p < 0.001$) with a large effect size ($r = 0.85$), indicating that the e-module effectively enhanced conceptual understanding, prompt-writing skills, and AI ethics. The effectiveness was supported by multimedia integration, project-based activities, and the Prompt RACE approach fostering reflective and contextual learning. The study contributes to strengthening AI literacy in vocational education and provides an adaptive e-module model applicable across vocational disciplines.

1. Introduction

The rapid development of artificial intelligence (AI), particularly chatbot technology such as ChatGPT, has opened up new opportunities for more personalized, adaptive, and interactive learning transformation (Yusriani & Fithriani, 2025). According to Lo (2023), ChatGPT has gained global attention thanks to its ability to generate coherent, systematic, and informative responses, as well as becoming the fastest-growing application in history in terms of user numbers. The potential of AI as a learning support tool is now being widely utilized in various educational contexts to help improve student learning outcomes through more independent and contextual learning experiences. Recent studies in the *Journal of Educational Sciences* also report that interactive e-modules and project-based e-modules can enhance learning outcomes and digital literacy through multimedia integration and self-directed activities (Hasibuan et al., 2025; Rosiana et al., 2023; Wahyuni et al., 2025). Based on a review of various studies, the application of artificial intelligence (AI) in education is still dominated by conceptual studies that focus on the integration of technology in learning, while empirical evidence regarding its effectiveness on learning outcomes is still limited (Weng et al., 2024a; Weng et al., 2024b; Yusop et al., 2022; Solak Berigel et al., 2024). Although studies on AI in education continue to develop, there is still very limited research that develops interactive Prompt Engineering e-modules to support AI-assisted learning for vocational students that are not only conceptual but also involve a systematic development process (4-D model) and are accompanied by testing of their effectiveness of learning outcomes. The effectiveness of interactive Prompt Engineering e-modules as learning media to facilitate AI-assisted learning that can measurably improve the learning outcomes of vocational students.

Although the potential of artificial intelligence (AI) in supporting adaptive learning in vocational high schools is increasingly recognized, a number of studies confirm that effective implementation at this level is still limited to the conceptual exploration stage without the support of a structured pedagogical model (Zhang & Tur, 2024; Bernacki et al., 2021). As a result, the use of AI in schools often occurs sporadically without clear pedagogical direction and has yet to show a significant impact on learning outcomes. Bernacki et al. (2021) highlight that although personalized learning is increasingly being adopted, the theoretical framework and practical guidelines are still underdeveloped, so that technology integration is often not based on explicit learning strategies. In line with this, Lee and Edwards (2025) emphasize that for AI to be truly effective in learning, teachers and students need to systematically understand Prompt Engineering skills to optimize their interaction with AI technology in learning activities. Therefore, there is a need to develop interactive learning media that not only introduces AI but also trains vocational students in designing and applying effective prompts to improve learning outcomes.

As one solution to the limitations of implementing artificial intelligence-based learning in vocational schools, the development of interactive Prompt Engineering e-modules is a relevant and contextual strategic step. This e-module is designed to equip vocational students with the skills to systematically design, test, and revise prompts when interacting with generative AI such as ChatGPT, so that the learning process becomes more focused and meaningful (Lee & Palmer, 2025; Federiakin et al., 2024). In addition, usability-oriented evaluation is essential in e-module development to ensure that learners can navigate interactive features effectively (Abdurrahman et al., 2025). In the context of vocational education, this ability is important because it helps students shift the position of AI from merely a technical tool to a thinking partner that enriches concept exploration and problem solving. In vocational classrooms, teachers are often faced with limited practice time and variations in students' initial abilities; therefore, the availability of e-modules that guide step-by-step interactions with AI is seen as a way to optimize learning sessions without adding to the teacher's workload excessively.

As the need for AI literacy in the workplace increases, Prompt Engineering needs to be taught explicitly so that students can optimally utilize technology in vocational learning (Knoth et al., 2024; Lee & Palmer, 2025). Without e-module-based guidance, learning activities with AI often involve trial and error and tend to make students dependent on ChatGPT answers without critical understanding of the reasoning process involved (Munaye et al., 2025). Through a project-based approach, vocational students can practice various prompt writing techniques that encourage meaningful interaction, reflective reasoning, and the development of higher-order thinking skills needed in the workplace. In this study, e-modules are designed not only as a collection of materials and exercises, but also as a safe space for students to experiment with prompts while reflecting on the results obtained. This approach is in line with the hermeneutic-pedagogical perspective that emphasizes the importance of critical reflection in human-AI interactions (Henrickson & Meroño-Peñuela, 2023) and forms the basis for the development of interactive learning media focused on improving vocational students' learning outcomes, as well as the basis for this study to test its effectiveness empirically.

Based on the above description, it can be concluded that there is still a research gap in the application of artificial intelligence in the context of vocational education, especially regarding the lack of structured learning media to systematically train Prompt Engineering skills. Therefore, this study explicitly aims to develop and test the effectiveness of AI-based interactive Prompt Engineering e-modules in improving vocational students' learning outcomes through a one-group pretest–posttest design, as a form of AI-based learning media innovation in vocational education. To achieve this objective, this study uses the Research and Development (R&D) method with the 4D model (Define, Design, Develop, Disseminate) proposed by Thiagarajan, Semmel, & Semmel (1974). This model includes the stages of defining needs, designing e-modules, developing through validation and testing, and disseminating products (Lestari, 2018). Thus, this study is expected to not only produce innovative and usable e-modules but also provide practical contributions to improving the learning outcomes and AI literacy of vocational students, as well as theoretical contributions to enriching studies on the integration of Prompt Engineering in AI-based learning in vocational education.

2. Methodology

This study uses the Research and Development (R&D) method with an emphasis on the process of developing digital learning media for vocational students. The main objective is to produce an interactive Prompt Engineering e-module as a companion in independent learning that facilitates the understanding of concepts and the effective application of prompts in the context of vocational education. The development process refers to the 4D model proposed by Thiagarajan, Semmel, and Semmel (1974), which includes four main stages, namely Define (definition), Design, Develop, and Disseminate, which systematically describe the steps from identifying needs to testing product effectiveness. The flow of stages in this 4-D model is visualized through a flowchart as shown in Figure 1.

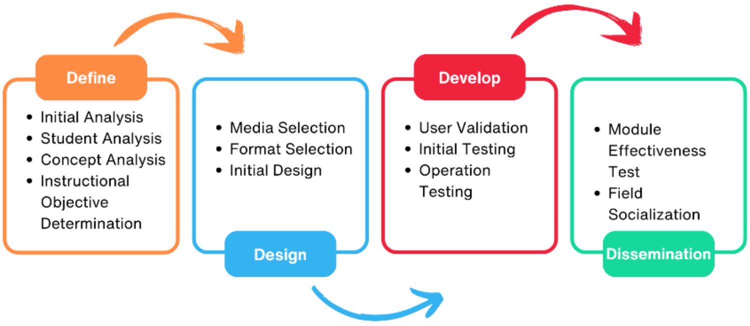


Figure 1. Thiagarajan 4D Model

Define

The Define stage aims to identify basic needs and formulate initial specifications for the development of interactive e-modules on Prompt Engineering for vocational students. This stage involves a series of analytical activities, including preliminary analysis, analysis of student characteristics, concept analysis, and setting instructional objectives. The preliminary analysis focuses on mapping the learning context and the digital media needs that can help students understand the basic concepts of Prompt Engineering independently. The analysis of student characteristics is aimed at exploring the profiles of vocational students in the field of information technology, including their initial abilities, learning habits, and readiness for technology-based learning. This definition stage is important to ensure that the e-module developed is truly relevant to the learning needs of students. In line with the views of Choi et al. (2023), a comprehensive needs analysis is very important to set learning objectives that address real needs and form the basis for the development of effective learning media.

Next, a concept analysis was conducted to determine the scope of the material and the structure of the module content. The material was developed by adapting Module 3 Prompt Engineering for Content Creation (Astuti et al., 2025), which covers the basics of generative artificial intelligence, elements and strategies for prompt composition, and ethics of its use. Based on the results of this analysis, instructional objectives were set so that students would be able to understand the basic principles of Prompt Engineering, compose prompts systematically, and apply them in a project-based learning context. This Define stage produced the conceptual basis used in the design of the content and structure of the e-module in the next Design stage.

Design

The Design stage aims to design an initial prototype of the Prompt Engineering interactive e-module tailored to the characteristics of vocational students as prospective users. The main activities in this stage include media selection, format determination, and initial design development. Media selection is geared toward the use of digital platforms capable of displaying text, audio, and visuals in an integrated manner, as well as supporting user interaction through exercises and quizzes. E-modules were chosen as the medium because they are flexible and allow participants to learn independently in a limited amount of time, in accordance with the needs of the effectiveness test conducted in a single meeting. The e-module format is designed to contain the main components, namely an introduction, pretest, material description, interactive worksheet-based exercises equipped with text, audio, and visual tutorials, interactive quizzes, a posttest (administered during the effectiveness test) completed individually under supervision without discussion; no assistance or feedback was provided during the assessment. To assess learning outcomes during the effectiveness test, a performance rubric was prepared based on the indicators provided in Module 3 of the official national training module (Astuti et al., 2025). The rubric indicators were mapped to the study's learning objectives and the task context was adapted to vocational students' characteristics.

Develop

The Develop stage focuses on the process of developing and validating the previously designed Prompt Engineering interactive e-module. Validation is carried out directly with users through two stages, namely one-on-one evaluation and small group evaluation (SGE). In the first stage, one vocational student is asked to use the e-module according to the prepared learning scenario. During the process, researchers note the difficulties, confusion, and feedback provided by users to improve the content, navigation, and clarity of instructions in the module. After revisions were made, the second stage, small group evaluation, was carried out by involving five to six vocational students using the same scenario. This evaluation aimed to assess the comprehensibility, ease of use, and consistency of the appearance and interactivity of the e-module in a more natural learning situation.

The input obtained from both validation stages was used to refine the e-module before conducting operational testing. Operational testing aimed to measure the effectiveness of the e-module on the learning outcomes of vocational students using a one-group pretest–posttest design. This activity was carried out in one meeting, beginning with a pretest, followed by a session of independent use of the e-module, and ending with a posttest administered under teacher/researcher supervision (proctored) and completed individually without discussion; no assistance or feedback was provided. The learning outcome assessment rubric was adapted from Module 3 of the official national training module (Astuti et al., 2025). The rubric provides structured indicators for prompt-engineering competencies; in this study, we ensured content alignment by mapping the indicators to the study's learning objectives and adapting the task context for vocational students. The Develop stage produced the final version of the interactive e-module, which was ready to be tested for effectiveness more widely in the Disseminate stage.

Disseminate

The Disseminate stage aims to test the effectiveness of the Prompt Engineering interactive e-module that has been validated in the previous stage, as well as to conduct limited dissemination of the development results to potential users. The effectiveness test is conducted to determine the extent to which the use of e-modules can improve the learning outcomes of vocational students in understanding and applying the concept of Prompt Engineering in the context of project-based learning.

Due to the authentic classroom context and the requirement that all students receive the same learning opportunity, a no-treatment control group was not feasible. Therefore, this developmental trial employed a one-group pretest–posttest design to provide preliminary evidence of learning gains following the e-module-supported activities. All participants first took a pretest to measure their initial abilities, then carried out independent learning using the interactive e-module, and subsequently took a posttest administered under teacher/researcher supervision and completed individually without discussion; no assistance or feedback was provided. Learning outcome data were obtained through a performance assessment rubric instrument containing five main aspects, namely: (1) understanding of prompt concepts, (2) analysis of prompt elements, (3) prompt improvement strategies, (4) ethics of AI use, and (5) application of prompts in a vocational context. Each aspect is scored from 1 to 4, with a maximum total score of 20, which is converted to a scale of 0 to 100 using the formula:

$$FInal\ Score = \frac{Score\ Earned}{20} \times 100$$

All student artefacts were scored by a single rater; therefore, inter-rater reliability could not be estimated in this study and is recommended for future research. Data analysis was conducted in two stages. (1) Descriptive analysis was used to calculate the mean and standard deviation (SD) of pretest and posttest scores. To determine the level of achievement of student learning outcomes in proportion to the actual value distribution, learning outcomes were categorized using Azwar's (2012) approach, as adapted in the e-module effectiveness study by Illah and Amelia (2025). This approach utilizes the mean (M) and standard deviation (SD) parameters to determine the learning outcome category intervals with the following criteria, as shown in Table 1.

Table 1. Learning outcome category intervals

Value Range	**Category**
$X \geq M + 1\ SD$	Excellent
$M \leq X < M + 1\ SD$	Good
$M - 1\ SD \leq X < M$	Moderate
$X < M - 1\ SD$	Poor

Note. X = individual score; M = mean; SD = standard deviation.

Inferential analysis is used to test the significance of differences in learning outcomes before and after treatment. Data normality tests are conducted first to determine the type of analysis to be used. If the data are normally distributed, the paired-samples t-test is used, whereas if the data are not normally distributed, the non-parametric Wilcoxon signed-rank test is used. The decision criteria are set at a significance level of 5% ($\alpha = 0.05$), where a Sig. (2-tailed) value ≤ 0.05 indicates a significant difference between the pretest and posttest scores. In this study, the normality test results showed that the data were not normally distributed, so the analysis of the difference between the pretest and posttest scores was continued with the Wilcoxon signed-rank test. In addition to statistical significance, this study also calculated the effect size r to see the practical strength of the influence. The r value is calculated from the Wilcoxon test statistic using the formula $r = \frac{Z}{\sqrt{N}}$ where Z is the Wilcoxon test statistic and N is the number of subjects analyzed (Tomczak & Tomczak, 2014). The r value is then interpreted using the following criteria: approximately 0.10 indicates a small effect, approximately 0.30 indicates a moderate effect, and ≥ 0.50 indicates a large effect.

3. Results and Discussion

Define

The Define stage aims to identify learning needs that form the basis for the development of interactive Prompt Engineering e-modules for vocational students. The analysis process was carried out through interviews with three educators in the field of vocational expertise and six students who are familiar with artificial intelligence technology. Based on the interview results, the educators stated that students are quite familiar with ChatGPT and often use it to help complete assignments, but they do not yet have an adequate understanding of the principles of prompt composition. In addition, there is no learning media that systematically teaches how to design effective prompts in the context of vocational learning. On the other hand, students admitted to experiencing confusion when using ChatGPT for learning purposes because they did not understand how to give clear and specific instructions. These findings indicate a need for learning media that can bridge the gap between the general use of AI and its application in the context of vocational learning.

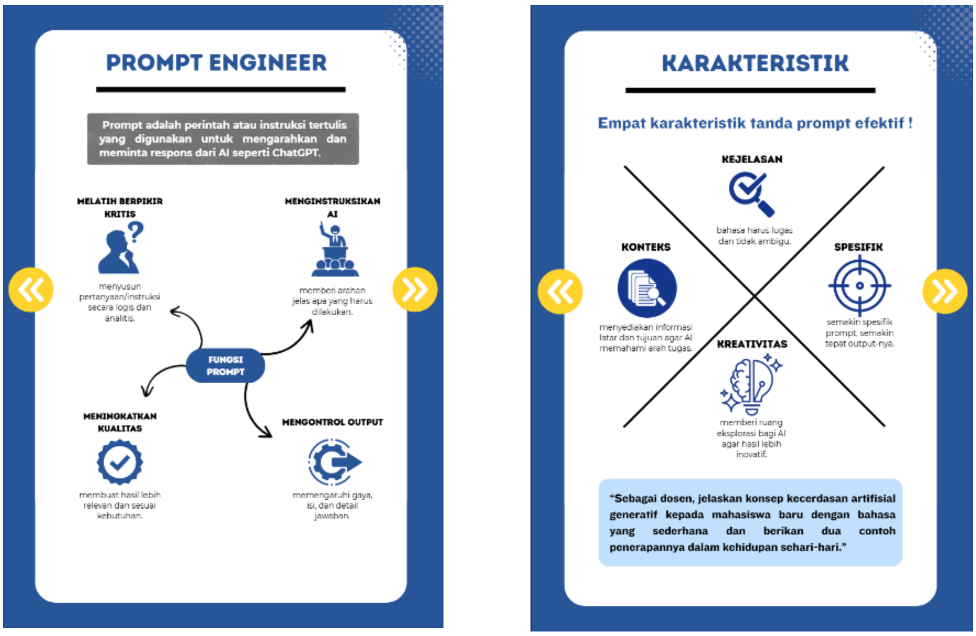
The interview results also revealed that both educators and vocational students have a high interest in interactive and easily accessible digital media. Students tend to understand the material more easily when accompanied by systematic learning guides in the form of text, audio, and visuals. Educators believe that interactive e-modules can be a solution to facilitate independent learning without reducing the role of instructional guidance. Based on these conditions, this study focuses on the development of interactive e-modules that not only present conceptual material but also provide students with direct experience in practicing and evaluating prompts independently.

To complement the results of the needs analysis, a document review was also conducted on Module 3 Prompt Engineering for Content Creation (Astuti et al.,

2025) as the main conceptual reference. The document analysis produced four key components that were adapted into the e-module, namely an introduction to the basics of Prompt Engineering, the elements and structure of effective prompts, prompt composition strategies such as zero-shot, few-shot, iterative prompting, and Prompt RACE, as well as ethics in the use of AI. These findings are in line with Walter's (2024) view that mastery of Prompt Engineering is a key competency in today's vocational education as part of AI literacy. The results of the Define stage then became the basis for designing the content structure, sequence of learning activities, and the development of interactive multimedia elements in the next Design stage.

Design

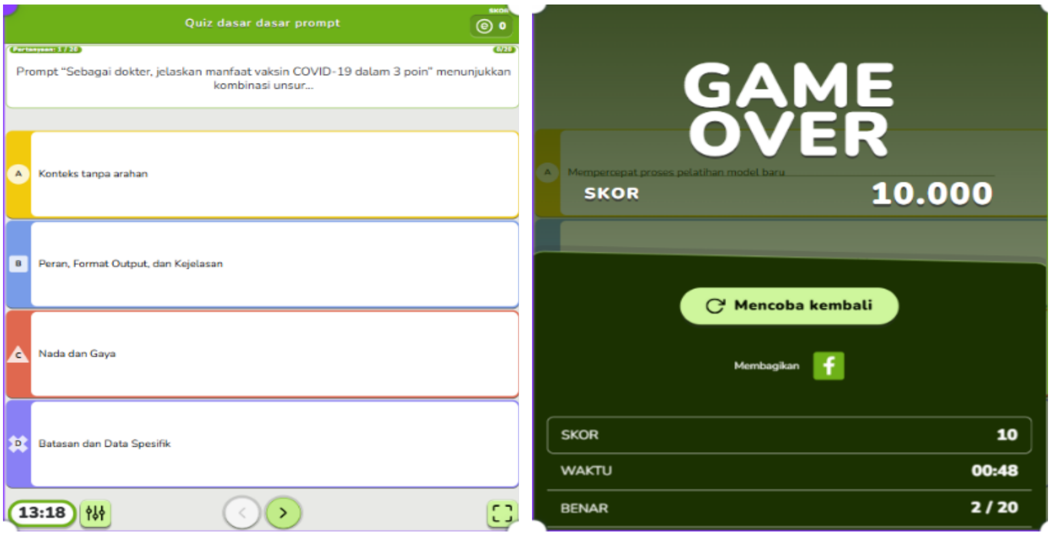
During the Design phase, an initial design for the Prompt Engineering interactive e-module was produced, tailored to the characteristics of vocational students and the learning objectives established during the Define phase. The e-module content was developed by adapting Module 3 of Prompt Engineering for Content Creation (Astuti et al., 2025) and implemented using the Canva and Quiz Creator platforms, which allow for the integration of text, video, animation, and interactive games. Each learning unit is designed to be completed in one session, making the e-module practical for use in effectiveness testing. To introduce the foundational content of the Prompt Engineering e-module, the basic material is presented in a concise visual format (Figure 2). Figure 2a provides a concept map summarizing the main functions of prompts in guiding AI responses, while Figure 2b outlines key characteristics of effective prompts—such as clarity, context, specificity, and creativity—that serve as criteria for evaluating and refining students' prompt construction.



(a) (b)

Figure 2. Basic Material Prompt

To support self-directed learning, the e-module embeds an in-module self-check quiz with immediate automated feedback (Fig. 3a–3b). _This quiz functions solely as a formative learning feature and was not used as the study's pretest/posttest instrument or as a data-collection measure_. Fig. 3a presents the interactive quiz interface used for students to practice identifying essential prompt elements and applying the Prompt RACE components, while Fig. 3b shows the automatic feedback and score displayed after completion to help students recognize errors and refine their prompt-writing consistency.



(a) (b)

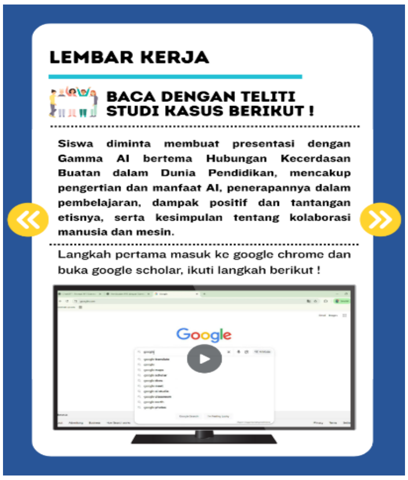
Figure 3. Interactive Quiz

This design stage shows that the integration of visual learning materials and interactive features in the e-module can strengthen the concept of independent learning and increase the engagement of vocational students. This is in line with the research by Nurhikmah et al. (2021), which states that the development of multimedia-based interactive e-modules can increase motivation and learning effectiveness because they are able to combine text, images, and audio-visual elements in an integrated manner. In this e-module, the basic concepts are presented visually (Fig. 2a–2b), and students are supported through an in-module self-check quiz with automatic feedback (Fig. 3a–3b) that functions as a formative learning feature rather than a research test instrument. With a design that integrates multimedia principles, this e-module is expected to gradually foster artificial intelligence literacy and prepare students to interact productively with AI technology. This design was then tested and validated in the Develop stage to assess its clarity, comprehensibility, and effectiveness in supporting improved learning outcomes.

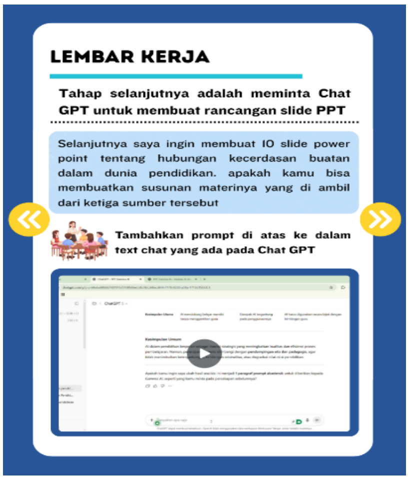
Develop

The Develop stage began with a user validation process aimed at assessing the comprehensibility, interface display, and smoothness of the interaction flow of students with the Prompt Engineering interactive e-module that had been designed.

Validation was carried out in two stages, namely one-on-one evaluation and small group evaluation (SGE). In the first stage, a vocational student was asked to use the e-module independently based on a prepared learning scenario. During the process, researchers noted the difficulties, confusion, and suggestions expressed by users, such as the need for clearer navigation icons and more concise instructions for use. After initial revisions, the second stage was carried out in the form of a small group evaluation involving six vocational students. This small group evaluation focused on aspects of display consistency, content comprehensibility, and interface interactivity. Based on the results of these two stages, several adjustments were made, such as improving the color design to make it more contrasting, and integrating interactive worksheets that function as video-based tutorial exercises to help students understand the steps for preparing prompts in stages. This worksheet feature is illustrated in Figure 4, which presents a step-by-step interactive prompt practice: (a) students review the task instructions and access the required resources, (b) students submit the prepared prompt to ChatGPT to generate an initial draft, and (c) students use the generated draft to create a presentation with Gamma AI following the guided tutorial.



(a)



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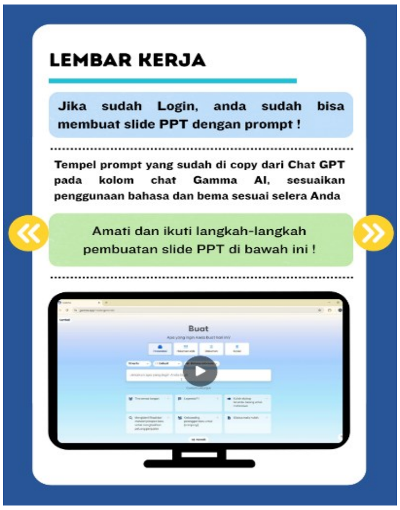

(c)

Figure 4. Interactive Prompt Practice

User validation results led to the development of worksheet-based exercises. Based on feedback from test participants, it was determined that the exercises should not only be conceptual quizzes, but should also involve hands-on practice in composing prompts. In response to this suggestion, the researchers added three interactive worksheets equipped with step-by-step video tutorials to guide students in using ChatGPT and Gamma AI. Each worksheet contains contextual instructions, case studies, and examples of prompt application in creating educational presentations. The design of these activities not only helps participants understand the theory of Prompt Engineering, but also accustoms them to practicing independently until they are able to apply the Role–Action–Context–Expectation structure in the context of vocational tasks.

After the validation and revision process of the e-module in the Develop stage is complete, an effectiveness test is conducted to assess the improvement in student learning outcomes. The learning outcome instrument used was adapted from Module 3 Prompt Engineering for Content Creation (Astuti et al., 2025), which contains standardized indicators on the aspects of concept understanding, application of prompt preparation strategies, and ethics of AI use. The case study-based posttest instrument used in this study is presented in Figure 5.

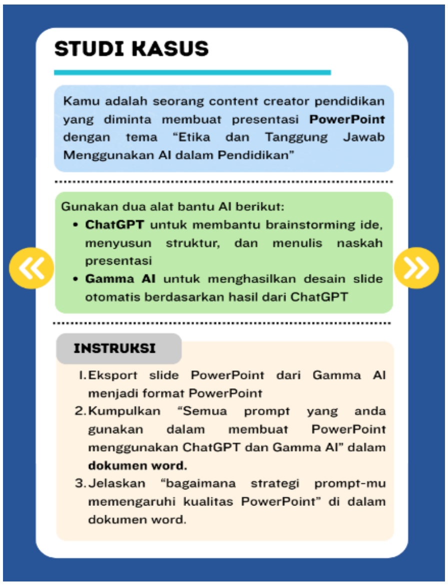

Figure 5. Case-Based Assessment Instrument for Prompt Engineering

Figure 5 shows a case study-based learning instrument that requires students to apply the concept of Prompt Engineering in authentic tasks. Participants are asked to take on the role of educational content creators who prepare a presentation on the theme of "Ethics and Responsibility in Using AI in Education" by utilizing ChatGPT to formulate ideas, structure, and presentation scripts, as well as Gamma AI to automatically generate visual designs. Through this task, participants are assessed not only on cognitive aspects, but also on critical thinking skills, the ability to compose effective prompts, and the application of ethical principles in the use of AI. Participants' work is evaluated using a rubric from Module 3 that assesses the suitability of objectives and outputs, the quality of prompt structure, project creativity, and learning reflection. The application of authentic case study-based tasks and rubric assessment shows that the interactive Prompt Engineering e-module developed in the Develop stage is suitable for use as a learning medium because it encourages engagement, conceptual understanding, and the application of Prompt Engineering principles in the context of real tasks. The final version of the e-module, which has been revised and tested with this instrument, is then used in the Disseminate stage, which focuses on implementation and socialization in a broader learning environment.

Disseminate

The Disseminate stage was carried out to test the effectiveness of the Prompt Engineering interactive e-module that had been developed in the previous stage. This effectiveness test aimed to determine the extent to which the use of e-modules could improve the learning outcomes of vocational students through independent learning based on digital interaction. The research design used at this stage was a one-group pretest–posttest design, with a total of 113 vocational students participating. All participants took a pretest before using the e-module, then carried out independent learning using the interactive e-module, and after that took a posttest administered under teacher/researcher supervision and completed individually without discussion; no assistance or feedback was provided. The assessment instrument used a five-aspect performance rubric covering concept understanding, prompt element analysis, improvement strategies, AI usage ethics, and prompt application in a vocational context. Each aspect was scored on a scale of 1–4 and converted to a scale of 0–100 to facilitate analysis. The learning outcome data were analyzed descriptively and inferentially to identify increases in average scores, learning outcome categories, and the significance of the differences between the pretest and posttest results.

The results of the descriptive analysis of the pretest and posttest scores are presented in Table 2. Based on the data processing results from 113 participants, the average pretest score was 67.52 (SD = 6.09) and the posttest score was 81.06 (SD = 5.41). The minimum and maximum scores ranged from 60 to 85 for the pretest and 65 to 95 for the posttest. The average increase of 13.54 points indicates a significant change after participants used the Prompt Engineering interactive e-module. In addition, the decrease in standard deviation from 6.09 to 5.41 indicates that participants' learning outcomes became more homogeneous after the intervention. In general, these findings show that the developed e-module had a positive impact on improving participants' ability to understand concepts, apply prompt engineering principles, and compose effective commands in a vocational context.

Table 2. Descriptive Statistics of Pretest and Posttest Learning Outcomes

Type of Test	n	Mean	SD	Minimum	Maximum
Pretest	113	67.52	6.09	60	85
Posttest	113	81.06	5.41	65	95

To determine the distribution of student learning outcomes based on achievement levels, posttest scores were categorized using the approach proposed by Saifuddin Azwar (2016). Based on the calculation results with a posttest score average (M = 81.06) and standard deviation (SD = 5.41), the determination of learning outcome category limits followed Saifuddin Azwar's (2016) classification formula. Participants with scores of $X \geq 86.47$ were categorized as excellent, $81.06 \leq X < 86.47$ as good, $75.65 \leq X < 81.06$ as fair, and $X < 75.65$ as poor. The distribution of participants in each category is presented in Table 3 below.

Table 3. Categories of Learning Outcomes Based on Azwar's Approach

Category	Range of Scor(	Frequency (f)	Percentage (%)
Excellent	X ≥ 86.47	36	31.9
Good	81.06 ≤ X < 86.⁄	41	36.3
Moderate	75.65 ≤ X < 81.(	31	27.4
Poor	X < 75.65	5	4.4
Total	**113**	**100**	

Based on Table 3, it can be seen that most participants were in the good and very good categories, accounting for 68.2% of the total respondents. Meanwhile, 27.4% of participants were in the fair category and only 4.4% were in the poor category. This distribution shows that after using the e-module, most participants had achieved a high level of mastery of prompt engineering concepts. These results are in line with the objectives of developing e-modules, which are designed to help participants learn independently and interactively in understanding the principles of effective and ethical prompt writing.

To assess whether the increase is inferentially valid, the next step is to examine the assumption of normality in the distribution of score differences (Δ = posttest − pretest). This normality test is necessary to determine the appropriate test—paired sample t-test if the assumption is met or Wilcoxon Signed-Rank Test if it is not met. The normality test was performed on the distribution of score differences (Δ = posttest − pretest) using Kolmogorov–Smirnov and Shapiro–Wilk. The results of the normality tests are presented in Table 4. The test results showed a significance value of $p < .001$ in both tests ($\alpha = 0.05$), indicating that the distribution of differences did not meet the assumption of normality. This condition is reasonable considering that the scores are limited to a discrete scale (multiples of 5) resulting from rubric conversion.

Table 4. Normality Test

Normality Test	Statistic	df	Sig. (p)
Kolmogorov–Smirnov[1]	0.161	113	< .001
Shapiro–Wilk	0.936	113	< .001

Based on these findings, the analysis of the differences between pretest and posttest scores was continued with a Wilcoxon signed-rank nonparametric test, which does not require the assumption of data normality. The test was conducted by pairing the total learning scores that had been converted to a scale of 0–100, so that the comparison between the pretest and posttest scores could be analyzed proportionally. The Wilcoxon signed-rank test results are summarized in Tables 5a and 5b. Table 5a presents the distribution of ranks (negative, positive, and ties), while Table 5b reports the test statistics, including the Z value, the two-tailed significance level (p-value), and the effect size (r).

Table 5a. Wilcoxon Signed-Rank Test Ranks (Pretest vs Posttest)

Rank Type	N	Mean Rank	Sum of Ranks
Negative Ranks (Post < Pre)	0	0.00	0.00
Positive Ranks (Post > Pre)	107	54.00	5778.00
Ties (Post = Pre)	6	—	—
Total	**113**		

Table 5b. Wilcoxon Signed-Rank Test Statistics (Pretest vs Posttest)

Statistic	Value
Z	−9.041
Asymp. Sig. (2-tailed)	$p < .001$
Effect size (r)	0.85

Based on the Wilcoxon signed-rank test results presented in Tables 5a and 5b, 107 of the 113 participants (94.7%) showed an increase in learning scores (positive ranks), 6 participants (5.3%) showed no change (ties), and none experienced a decrease (negative ranks = 0). The test yielded $Z = -9.041$, $p < .001$, indicating a statistically significant difference between the pretest and posttest scores. The improvement was accompanied by a large effect size ($r = 0.85$), indicating a substantial pre–post gain in learning outcomes following the e-module-supported learning activities. These findings suggest that the e-module may support students' understanding and application of prompt-engineering principles in a systematic and contextual manner, and provide a basis for further discussion of the theoretical and practical implications of the research results.

Discussion

The effectiveness test results suggest a substantial pre–post improvement in vocational students' learning outcomes following the use of the Prompt Engineering interactive e-module. This can be seen from the difference in scores before and after learning and the effect size, which is in the large category. These findings indicate that e-module-based learning is capable of creating a meaningful learning experience that stimulates conceptual understanding as well as procedural skills in applying the principles of Prompt Engineering. A plausible explanation is the integration of interactive multimedia components and project-based exercises that activate dual coding processes, as stated by Mayer (2024). Students not only receive information but also engage in reflective activities through quizzes and digital worksheets that encourage long-term memory reinforcement and the ability to transfer knowledge to new contexts.

The effectiveness obtained also shows consistency between the conceptual design and the application of the 4-D model adapted from Thiagarajan et al. (1974). A systematic approach, starting from needs analysis to user validation, ensures that the resulting product is in line with the characteristics and digital readiness of vocational students. The gradual validation process and interface revisions based on user feedback may have strengthened usability and increase learner engagement. This shows that the quality of learning design has a direct contribution to improving learning outcomes, as emphasized by Choi et al. (2023) that the effectiveness of digital media is determined by the suitability of content, appearance, and user context. Thus, the success of this e-module stems not only from the content of the material, but also from the design of interactivity that supports independent and contextual learning.

Consistent with prior literature, prompt engineering has been positioned as an important component of AI literacy and can support more purposeful and critical engagement with generative AI in learning (Lee & Palmer, 2025; Knoth et al., 2024; Federiakin et al., 2024). Empirically, structured prompt training has also been reported to improve students’ task performance compared with unguided GenAI use or non-GenAI controls (Garg et al., 2025). In the present study, the Prompt RACE (Role, Action, Context, Expectation) scaffolding, combined with interactive multimedia and project-based activities, was followed by a significant pre–post gain with a large effect size ($r = 0.85$), suggesting substantial within-group improvement in vocational students’ learning outcomes. Nevertheless, given the one-group pretest–posttest design, this effect size should be interpreted as preliminary evidence rather than a causal estimate.

Theoretically, this study enriches the framework of artificial intelligence literacy (AI literacy) by emphasizing that Prompt Engineering can be used as a new pedagogical foundation for building reflective and ethical thinking skills in interacting with AI technology. This approach is in line with the hermeneutic-pedagogical views of Henrickson and Meroño-Peñuela (2023), which place humans as active subjects in the process of technological meaning, not merely passive users. In practical terms, the interactive e-module developed can be a reference for vocational teachers in integrating contextual and adaptive AI-based learning. With the support of standardized evaluation instruments and a user-friendly interface, this e-module can be applied in both classroom and independent learning. This research also opens up opportunities for further development through the integration of learning analytics to continuously monitor students' AI literacy development, as well as expanding its application to other areas of expertise in vocational education.

Although the results of the study show strong effectiveness, these findings have several limitations that need to be considered. First, the one-group pretest–posttest research design without a control group was not fully able to isolate the influence of external factors on learning outcome improvement. Second, the limited context of the trial to one vocational field means that the results need to be generalized with caution. Thus, the findings of this study are best understood as preliminary evidence that still requires replication in schools, skill programs, and more diverse learning settings. In addition, the short duration of the intervention does not yet describe the long-term impact on knowledge retention and prompting skills. In the future, further research can expand the scope of participants, apply experimental designs with stricter controls, and integrate learning analytics to assess the development of AI literacy longitudinally. Thus, the results of this study still provide an important foundation for the development of AI-based pedagogy in vocational education, while opening up further exploration to ensure its sustainability.

Several uncontrolled factors may also have contributed to the observed pre–post gains. First, a testing effect may have occurred, as exposure to the pretest could have increased students' familiarity with the task format and rubric expectations, which may elevate posttest performance regardless of the intervention. Second, novelty and expectancy (e.g., heightened attention because students were using a new interactive e-module and AI tools) may have temporarily boosted engagement and effort. Third, although the assessments were proctored and completed individually without discussion, students may have been influenced by prior experiences with generative AI or by external learning resources accessed outside the session. Finally, teacher/researcher presence during implementation may have encouraged better on-task behavior (a Hawthorne-like effect). Therefore, the observed improvement should be interpreted as preliminary evidence of within-group gains, which warrants confirmation through controlled designs and broader implementations.

4. Conclusion

This study aimed to develop and evaluate an interactive Prompt Engineering e-module to support AI-assisted learning for vocational students, and the findings indicate that this objective was achieved. Through the 4-D development model, the resulting e-module is pedagogically structured, aligned with the characteristics of vocational learners, and integrates multimedia content, the Prompt RACE framework, and project-based activities with authentic AI-supported tasks. The implementation of the e-module was associated with deeper understanding of prompt concepts, more effective prompt construction, and more ethical use of generative AI tools, while also supporting engagement and independent learning. In practical terms, the final version of the e-module can be used as a learning resource in classroom settings or for self-directed study, as well as a reference model for integrating AI literacy into vocational curricula. This study is limited by the one-group design, the focus on a single vocational field, and the short intervention duration; therefore, future studies should use controlled designs and broader implementations. Overall, the e-module offers a practical and adaptable model for strengthening prompt literacy and responsible generative-AI use in vocational education, supporting students' readiness for AI-shaped workplaces.

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