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Development of a SETS-Based Creativity, Innovation, and Entrepreneurship Electronic Module to Improve Students' Critical Thinking Skills

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Abstract: This study aims to analyze the development process, feasibility, student responses, and effectiveness of the Creativity, Innovation, and Entrepreneurship (KIK) e-module based on the SETS (Science, Environment, Technology, Society) approach in improving critical thinking skills of eleventh-grade vocational high school (SMK) students in Surabaya. The research method used is Research and Development (R&D) by adopting the 4-D model (Define, Design, Develop, Disseminate) combined with True Experimental Design (Pretest-Posttest Control Group Design). The research subjects involved 232 students in five SMKs in Surabaya. Data were analyzed quantitatively through normality tests, paired sample t-tests, independent sample t-tests, and Cohen's d effect size calculations. The results of expert validation showed that the e-module was very feasible to use with a percentage of 97% from material experts, 95% from language experts, and 74% from graphic experts. Student responses confirmed high practicality with a score of 94%. An independent sample t-test showed a significant difference in critical thinking posttest scores between the experimental and control groups ($p < 0.05$). The average N-Gain score in the experimental class reached the "High" category (0.79–0.82), while the control class remained in the "Medium" category (0.52–0.71). Cohen's d analysis yielded a value of 1.42, indicating a strong effect size. The theoretical contribution and novelty of this study lies in the integration of the Science, Environment, Technology, and Society (SETS) approach into an interactive entrepreneurship e-module for vocational education, combined with experimental testing in various schools. This study demonstrates that SETS-based digital teaching materials can serve as an effective pedagogical innovation to support active, contextual, and critical learning in vocational entrepreneurship education.

Keywords: E-module, SETS, Critical Thinking, Entrepreneurship, Vocational High School

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INTRODUCTION

Education plays a strategic role in preparing human resources capable of responding to social, economic, and technological changes (Muthoharoh & Sakti, 2021) . In the contemporary educational context, curriculum transformation requires teachers to use adaptive and innovative learning resources that support active learning and higher-order thinking. In Indonesia, the

implementation of the Independent Curriculum emphasizes flexible, student-centered learning and the development of competencies relevant to 21st-century demands (Kumalasari et al., 2024). These demands include not only the acquisition of knowledge but also the ability to analyze problems, evaluate information, and make reasoned decisions. These competencies are closely related to critical thinking skills, which are increasingly considered an important outcome of vocational education. In Indonesia, the implementation of the Independent Curriculum emphasizes flexibility, student-centered learning, and the development of competencies relevant to 21st-century demands. These demands include not only the acquisition of knowledge but also the ability to analyze problems, evaluate information, and make reasoned decisions. These competencies are closely related to critical thinking skills, which are increasingly considered an important outcome of vocational education (Facione, 2011).

However, initial interviews with Creativity, Innovation, and Entrepreneurship teachers at vocational high schools in Surabaya revealed that classroom teaching is still dominated by conventional, teacher-centered approaches. This tends to limit students' active involvement in constructing knowledge and can reduce opportunities for inquiry, reflection, and problem-solving. As a result, the development of critical thinking skills is not optimally facilitated. (Surasa et al., 2017). Previous studies have shown that passive learning environments dominated by information transfer are less effective in encouraging critical thinking compared to learning designs that engage students in authentic analysis and decision-making.

One learning innovation that can address this challenge is the use of digital teaching materials, particularly e-modules. E-modules provide flexible access, multimedia integration, and opportunities for self-directed learning (Ashari & Puspasari, 2024) . In vocational education, digital modules are particularly relevant because they can present contextual problems, interactive assignments, and practical scenarios aligned with real-world workplace and entrepreneurial situations. (Huldan, 2025) . More importantly, the effectiveness of e-modules depends not only on their digital format but also on the pedagogical logic embedded within them. Therefore, the development of digital teaching materials must be integrated with a learning approach that encourages students to connect concepts to real-world situations and to think systematically about the problems they might face in society. (Kustanti et al., 2023)

A relevant framework for this purpose is the Science, Environment, Technology, and Society (SETS) approach. SETS positions learning as a process connecting scientific reasoning, environmental awareness, technology utilization, and social consequences. Through this approach, students are encouraged to examine problems from multiple perspectives and develop solutions that are not only technically feasible but also socially and environmentally responsible (Novandi et al., 2025) . In entrepreneurship learning, this orientation is crucial because business ideas and innovations are always situated within broader technological trends, ecological constraints, and societal needs. Therefore, the SETS approach offers strong conceptual alignment with the goals of entrepreneurship education in vocational schools. (Pratiyaksi, Ni Made Diantari, 2024) .

Critical thinking has become a key competency for vocational students because entrepreneurship subjects require students to identify opportunities, assess risks, interpret market information, and formulate applicable solutions. (Novandi et al., 2025) . These tasks require analysis, inference, evaluation, and reflective judgment. In this regard, entrepreneurship learning should not be limited to procedural business knowledge alone, but should train students to make rational, evidence-based decisions (Idris, 2023) . Studies on critical thinking consistently show that these skills develop more effectively when students engage in authentic, contextual, and problem-oriented learning experiences. (Saputro et al., 2022) .

Several previous studies have addressed e-modules, SETS-based learning, and critical thinking in separate contexts. However, this study's contribution differs in several important ways. First, it developed an interactive e-module specifically for the Creativity, Innovation, and Entrepreneurship course in vocational high schools. Second, this module integrates the SETS approach not merely as a conceptual label, but as an organizing principle for content presentation,

case analysis, learning activities, and evaluation. Third, this product was not only developed and validated through R&D but also experimentally tested in five vocational high schools, allowing for broader evidence of its effectiveness. Thus, the novelty of this study lies not only in the creation of a digital module but also in demonstrating how a SETS-based entrepreneurship e-module can serve as a contextual pedagogical intervention to enhance students' critical thinking skills in vocational education.

Based on these reasons, this study aims to test:

(1) SETS-based e-module development process;

(2) its suitability based on expert validation;

(3) its practicality based on student responses; and (4) its effectiveness in improving the critical thinking skills of eleventh grade students at vocational schools in Surabaya.

METHOD

This study uses the Research and Development (R&D) method (Sugiyono, 2016) which is adapted from the 4-D development model proposed by Thiagarajan, Semmel, and Semmel (Trianto, 2007) which consists of defining, designing, developing, and disseminating. The use of this model is intended to ensure that the product is developed systematically before being tested for its effectiveness in a classroom environment.

Development procedures

1. In the definition stage, the researchers conducted a preliminary analysis consisting of curriculum analysis, student characteristics analysis, concept analysis, and task analysis. This stage aimed to identify learning issues in Creativity, Innovation, and Entrepreneurship, particularly those related to the limited use of contextual digital learning materials and the low optimization of students' critical thinking skills.
2. During the design phase, the researchers prepared the structure and learning flow of the electronic module. The module is designed as an interactive, web-based learning resource using digital platforms such as Canva and Heyzine Flipbook. Module components include an introduction, learning objectives, SETS-based contextual materials, student activities, case analysis, assessment items, and a glossary. The learning content structure is aligned with SETS principles so students can connect entrepreneurial concepts with scientific reasoning, environmental considerations, technological developments, and social realities.
3. During the development phase, the prototype was reviewed and validated by three experts: a content expert, a linguist, and a graphics expert. The validation process focused on content suitability, linguistic clarity, visual design, navigation quality, and integration of SETS principles. The validators' suggestions were used to revise the e-module before implementation. Additionally, a pilot test involving 20 students was conducted to examine the module's initial readability, usability, and practicality. At this stage, the critical thinking test instrument was also tested for validity and reliability using Pearson's product-moment correlation and Cronbach's alpha.
4. In the dissemination phase, the final revised e-module was implemented in five vocational high schools in Surabaya. Dissemination in this study was limited to educational use in participating schools and distribution of the validated product to teachers and students involved in the study.

Experimental design

After the development process was completed, the effectiveness of the e-module was tested using a pretest-posttest control group design. The experimental class was taught using the

SETS-based e-module, while the control class received conventional instruction without the module. This design was chosen to compare learning outcomes between students who received the intervention and those who did not.

This study involved five vocational schools in Surabaya, namely SMK Pawiyatan, SMK Ipiems, SMK PGRI 10, SMK PGRI 13, and SMK Adhikawacana. The research subjects are presented in Table 1.

Table 1. Research Subjects

School name	Control Class	Sample(n)	Experimental Class
Pawiyatan Vocational School	XI DKV 1	23	XI RPL 1
Ipiems Vocational School	XI MP 2	34	XI MP 1
PGRI 10 Vocational School	XI PSPT 2	21	XI PSPT 1
PGRI 13 Vocational School	XI BD 1	21	XI BD 2
Adhikawacana Vocational School	XI MPK 2	24	XI MPK 1
Total Sample(N)		113	

Source: Processed Primary Data (2026)

Sampling and group assignment

Class selection was conducted at the school level based on the availability of parallel classes and school approval for the study. The control and experimental groups were selected from the equivalent 11th graders in each school.

Instrument

Three categories of instruments were used in this study:

1. Expert validation sheet, using a Likert scale of 1-5 (Riduwan, 2016) , to assess the feasibility of e-modules in terms of content, language, and graphics.
2. Student response questionnaire, to evaluate the practicality and user acceptance of the e-module after implementation.
3. Critical thinking test, consisting of 20 items at cognitive levels C4, C5, and C6, to measure students' critical thinking abilities before and after treatment.

Data analysis

Feasibility and practicality data were analyzed descriptively using percentage criteria. Effectiveness data were analyzed quantitatively using IBM SPSS. The analysis procedures included:

1. Shapiro-Wilk normality test to check whether the pretest and posttest scores are normally distributed;
2. Paired sample t-test to identify the difference between pre-test and post-test scores in the experimental class;
3. test to compare post-test results between control and experimental classes; and
4. Normalized Gain (N-Gain) to determine the extent of increase in students' critical thinking skills.

To strengthen statistical reporting, presentation of findings should ideally include the number of students in each class, mean score, standard deviation, and effect size in addition to the significance value.

RESULTS AND DISCUSSION

Research result

E-Module Eligibility

Product validity was evaluated by three expert validators from Surabaya State University. Quantitative verification is summarized in Table 2.

Table 2. Summary of Product Feasibility Validation Results

Validator Expert	Feasibility Aspects	Assessment	Score Ratio	Validity Percentage	Interpretation Criteria

Subject matter expert Dr. Norida Canda Sakti, M.Si.	Content quality, CP-ATP alignment, instructional design, SETS stimulation, and presentation flow.	73 / 75	97%	Very Worthy
Linguist Andik Yuliyanto, SS, M.Si.	Cognitive readability, vocabulary appropriateness, motivational phrases, and syntactic coherence.	62 / 65	95%	Very Worthy
Graphic Expert Nova Kristiana, S.Sn. , M.Sn.	Visual layout, navigation mechanics, typographic color harmony, and cover aesthetics.	37 / 50	74%	Worthy

Source: Processed Primary Data (2026)

Practicality of Electronic Modules

The practicality of the e-module was determined through a user response questionnaire distributed to the experimental group (n = 119) after completing the KIK learning cycle. Across 15 core technical, aesthetic, and interactive indicators, the e-module achieved an aggregate practicality score of 94%, which places it in the "Very Feasible and Practical" classification for supporting independent learning in the classroom.

Critical Thinking Skills Test Results

Empirical comparisons of students' critical thinking parameters, including sample size (n), mean pretest/posttest scores, and standard deviation (SD) for the experimental and control groups in the five participating vocational schools, are consolidated in Table 3.

Table 3. Comparison of Average Test Scores of Control and Experimental Classes

School name	Group	Sample	Pretest Average	Elementary School Pretest	Posttest Average	SD Posttest
Pawiyatan Vocational School	Control	23	44.30	8.12	75.14	6.89
	Experiment	23	40.80	7.45	82.10	5.44
Ipiems Vocational School	Control	24	50.00	9.03	72.84	7.12
	Experiment	24	43.88	8.76	81.80	5.92
PGRI 10 Vocational School	Control	21	50.00	7.65	76.36	6.45
	Experiment	21	45.41	8.11	83.50	5.18
PGRI 13 Vocational School	Control	21	47.10	8.44	76.82	6.30
	Experiment	21	46.82	7.90	84.20	5.22
Adhikawacana Vocational School	Control	24	47.00	8.90	74.92	7.20
	Experiment	24	42.21	8.23	82.00	5.80

Source: Processed Primary Data (2026)

Statistical Analysis of Effectiveness (Normality Test, t-Difference Test, and N-Gain Score)

Normality Test: Data distribution was tested using the Shapiro-Wilk method which is highly accurate for sample subsets where n < 50. The normality coefficients are presented in Table 4.

Table 4. Comparison of Average Test Scores of Control and Experimental Classes

School name	Data Group Variables	Statistics	df	Sig. (p-value)
Pawiyatan Vocational School	Pretest Control	.935	23	.142
	Posttest Control	.971	23	.714
	Experiment Pretest	.980	23	.907
	Experiment Posttest	.956	23	.388
Ipiems Vocational School	Pretest Control	.984	24	.957
	Posttest Control	.952	24	.301
	Experiment Pretest	.946	24	.217
	Experiment Posttest	.960	24	. 434
PGRI 10 Vocational School	Pretest Control	.938	21	.195
	Posttest Control	.935	21	.175
	Experiment Pretest	.940	21	.220
	Experiment Posttest	.952	21	.365
PGRI 1 3 Vocational School	Pretest Control	.946	21	.285
	Posttest Control	.960	21	.508
	Experiment Pretest	.950	21	.334
	Experiment Posttest	.946	21	.291
Adhikawacana Vocational School	Pretest Control	.956	24	.360
	Posttest Control	.954	24	.332
	Experiment Pretest	.978	24	.860
	Experiment Posttest	. 985	24	.969

Source: Processed Primary Data (2026)

As shown in Table 4, all calculated significance values (p-values) exceed the critical threshold of 0.05. Thus, the null hypothesis for non-normality is rejected, confirming that all datasets are normally distributed and suitable for inferential parametric testing.

Paired Samples t-Test: This test evaluates cognitive growth in the experimental class before and after being given the SETS digital e-module treatment. In the following table:

Table 5. Consolidation of Paired Sample t-Test Results for Experimental Class

School name	**Paired Variables**	**Average Difference**	**Elementary School**	**t value**	**df**	**Sig. (2-tailed)**
Pawiyatan Vocational School	Pretest - Posttest	-41,304	9,441	-20,982	22	.000
Ipiems Vocational School	Pretest – Posttest	-37,917	13,507	-13,753	23	.000
PGRI 10 Vocational School	Pretest – Posttest	-38,095	9,148	-19,083	20	.000
PGRI 13 Vocational School	Pretest – Posttest	-37,381	8,749	-19,579	20	.000
Adhikawacana Vocational School	Pretest - Posttest	-39,792	10,782	-18,079	23	.000

Source: Processed Primary Data (2026)

The Paired Sample t-test across all five institutions produced a uniform p-value, namely 0.000 < 0.05. This shows that the implementation of the SETS-based KIK e-module caused a statistically significant increase in students' critical thinking scores.

Independent Samples t-Test: This procedure is used to compare the posttest performance of the experimental group to the control group to confirm the success of the intervention:

Table 6. Consolidation of Independent Sample t-Test Results

School name	Levene's Test (Sig.)	t value	df	Sig. (2-tailed)	Difference
Pawiyatan Vocational School	.876	-3,356	44	.002	-6,957
Ipiems Vocational School	.036	-4,275	38.65	.000	-8,958
PGRI 10 Vocational School	.209	-3,478	40	.001	-7,143
PGRI 13 Vocational School	.872	-3,133	40	.003	-7,381
Adhikawacana Vocational School	.782	-3,083	46	.003	-7,083

Source: Processed Primary Data (2026)

The test results showed that the 2-tailed significance value was consistently below 0.05 (p < 0.05) across all five vocational school settings. This provides empirical evidence that the experimental group achieved significantly higher posttest critical thinking capacity than the control group using conventional methods.

N-Gain Score Effectiveness Analysis: To measure the acceleration of cognitive growth and the magnitude of the intervention effect, the Normalized Gain (N-Gain) index and Cohen's d were calculated.

Table 7. Normalized Gain (N-Gain) Values and Class Classification

School name	Average N-Gain (Control)	Criteria	Average N-Gain (Experiment)	Criteria
Pawiyatan Vocational School	0.68	Medium	0.79	High
Ipiems Vocational School	0.64	Medium	0.80	High
PGRI 10 Vocational School	0.52	Medium	0.80	High
PGRI 13 Vocational School	0.71	High	0.82	High
Adhikawacana Vocational School	0.67	Medium	0.80	High

Source: Processed Primary Data (2026)

The data show that the experimental cohort achieved an average N-Gain between 0.79 and 0.82, which falls into the High growth category. In contrast, the control group mostly fell within the Medium growth index (0.52 to 0.71). To determine the practical significance of these gains, Cohen's d effect size was calculated. The resulting combined value of 1.42 (d > 0.8) indicates

a very strong effect size, demonstrating that the digital SETS intervention had a substantial practical impact on learning.

Discussion

The findings of this study indicate that the developed SETS-based e-module is feasible, practical, and effective in improving vocational students' critical thinking skills. These findings can be interpreted not only from the perspective of digital media use but also from the pedagogical structure embedded within the module (Dwivedi et al., 2021) .

First, the robust feasibility study results indicate that the product was systematically designed in accordance with the content and instructional requirements. The product's feasibility, assessed by a team of material, language, and graphic experts, yielded an average score above the minimum effectiveness criteria. The highest validity scores from the material experts (97%), language experts (95%), and graphic experts (74%) were driven by the depth of integration of SETS values that were harmoniously incorporated into each core KIK material. The high scores from the material experts indicate that the e-module successfully aligns entrepreneurship content with SETS-oriented learning activities. Developing substantively valid content is crucial, given that the failure of teaching materials is often caused by the media's inability to present a logical and coherent material structure (Branch & Merrill, 2012) . In vocational entrepreneurship education, learning materials need to go beyond conceptual explanations and should place learning in authentic economic and social contexts. This contextualization has proven crucial to bridge the gap between theoretical knowledge in schools and practical skills needed in the industrial world (Winborg & Hägg, 2023) .

Second, reviewing the practicality indicator from student responses, an average score of 94% confirms the product's high user-friendliness. A high practicality score indicates that students found the e-module easy to access, understand, and engaging. Ease of navigation and adaptive visual presentation are key elements in retaining the attention of Generation Z students in digital learning environments (Haleem et al., 2022) . The use of interactive digital platforms such as Canva and Heyzine Flipbook likely contributed to this positive response by enabling multimodal presentation of materials. However, the effectiveness of the module should not be attributed solely to its digital format. Digital presentations may be eye-catching, but the deeper learning impact comes from how students are cognitively guided through contextual problem-solving tasks. Interactive learning media will remain merely passive visual tools if not accompanied by cognitive stimulation that challenges students to think independently (Mayer, 2024) . Research on digital learning consistently shows that technology becomes educationally meaningful when combined with clear instructional design and active learning opportunities.

Third, the improvement of critical thinking skills can be theoretically explained through the internal logic of the SETS approach. Learning that simultaneously integrates multiple aspects has been shown to stimulate students' thinking flexibility in solving complex 21st-century problems (Lee & Erdogan, 2007) . Each SETS component provides a different cognitive function in entrepreneurship learning. The Science component encourages students to analyze entrepreneurial problems logically, identify cause-and-effect relationships, and evaluate product or business ideas based on evidence. This scientific and objective reasoning is crucial for minimizing the risk of speculation in business decision-making (Bauman & Lucy, 2021) . The Environmental component trains students to consider sustainability, ecological consequences, and responsible production practices when formulating business solutions. This integration of ecological awareness is highly relevant to the global trend of green entrepreneurship, which

demands that future entrepreneurs not only pursue profit but also minimize negative impacts on ecosystems (Schaltegger et al., 2016) . The Technology component encourages students to think about digital tools, innovation processes, market access, and the role of technological change in entrepreneurial competitiveness. Mastery of the technological aspects in this module helps students design digital-based business strategies (e-commerce) that are adaptive to the era of economic disruption (Nambisan, 2017) . The societal component guides students to evaluate whether a business idea is socially relevant, ethically acceptable, and responsive to community needs. This social sensitivity ensures that the innovations created by students have real use value (social value creation) and high acceptance in the domestic and international markets (Mair & Marti, 2006) . Through the interaction of these four components, students not only receive information but are also required to examine problems from various dimensions. This multidimensional analysis is closely related to the core elements of critical thinking, including interpretation, analysis, inference, explanation, and evaluation.

Significant differences found in both paired-sample and independent-sample t-tests indicate that the module supported measurable learning gains. Consistent post-treatment score increases indicate that the e-module intervention significantly minimized student misconceptions (Creswell & Creswell, 2017) . Furthermore, high N-Gain scores across all experimental classes indicate that the gains were not coincidental or limited to one school context. The consistent success across these five schools provides strong evidence of the product's reliability and generalizability when applied to diverse student input characteristics. (Fraenkel & Wallen, 1990) . This consistency across schools strengthens the argument that e-modules have practical instructional value for vocational entrepreneurship education.

Theoretically, these findings support the view that critical thinking develops more effectively when students engage in contextual, inquiry-oriented, and problem-based learning environments. Higher-order thinking skills (HOTS) cannot be inherited through passive instruction but must be triggered through authentic, real-world problem-solving dilemmas (Ennis, 1985) . In this study, the SETS-based e-module served as a structured pedagogical tool that connected entrepreneurship content to real-world issues, encouraging students to question assumptions, justify decisions, and reflect on alternative solutions. These activities of in-depth reflection and argumentative evaluation stimulated students' metacognitive regulation, accelerating their self-regulated learning (Zimmerman & Schunk, 2013) . This confirms that the observed learning gains resulted not only from exposure to digital media but also from the pedagogical integration of SETS principles into entrepreneurship instruction.

Therefore, the novelty of this study lies in three interrelated contributions. First, this study develops a digital entrepreneurship module specifically for learning in vocational high schools. Second, this study operationalizes the SETS framework within an interactive e-module structure, rather than simply applying it as a general teaching approach. Third, this study experimentally tests the product in five schools, providing broader empirical evidence of its effectiveness. These combined contributions make this study more than a conventional R&D product development report; it positions it as a study of pedagogical innovation in vocational entrepreneurship education.

CONCLUSION

Based on the entire series of research and development data analysis conducted, several basic conclusions can be drawn as follows:

1. The SETS-based KIK e-Module development process was successfully implemented through four stages of the 4-D model (Define, Design, Develop, Distribute) by utilizing the Canva and Heyzine Flipbook platforms to create interactive web-based modules.
2. The e-module's suitability is categorized as very valid and suitable for implementation, based on the validity percentage obtained from material experts (97%), language experts (95%), and graphics experts (74%).
3. Practical responses from students showed the criteria of "Very Suitable" with a score of 94%, proving that this interactive e-module is easy to understand and practical to use to support independent learning.
4. This module was proven effective in improving the critical thinking skills of eleventh-grade vocational high school students in Surabaya, as indicated by significant posttest gains ($p < 0.05$). The experimental class achieved high levels of N-Gain scores (0.79–0.82), consistently outperforming the conventional control group.

These findings suggest that integrating the SETS approach into interactive digital teaching materials can serve as an effective pedagogical innovation in vocational entrepreneurship education. The developed e-modules not only support digital learning but also encourage contextual, reflective, and critical thinking processes, which are crucial for 21st-century vocational students.

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