

DEVELOPMENT OF FLIPBOOK-BASED INTERACTIVE E-MODULE TO IMPROVE STUDENTS' UNDERSTANDING OF GRADE X VOCATIONAL SCHOOL WORK PRACTICE MATERIAL

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ABSTRACT

The limited availability of interactive learning media in vocational schools can impede students' comprehension of bench work procedures prior to conducting practical activities. This study sought to develop a Flipbook-based interactive e-module equipped with multimedia elements to enhance Grade X vocational students' understanding of bench work practice materials. The research employed a Research and Development (R&D) method using the ADDIE development model and involved 50 Grade X students at SMK Muhammadiyah 2 Semarang. Data were obtained from expert validation, teacher and student response questionnaires, as well as pretest and posttest assessments. The findings demonstrated that the developed e-module met a very high level of validity, as indicated by scores of 87.79% from media experts, 84.90% from material experts, and 89.95% from assessment experts. In terms of practicality, the e-module received scores of 89.38% from teachers and 88.62% from students, indicating a very practical level. The results of the paired sample *t*-test also revealed a statistically significant increase in students' understanding ($p < 0.05$). Moreover, the experimental class obtained an average N-Gain score of 65.23%, which was classified as moderately effective. Overall, the findings suggest that the Flipbook-based interactive e-module is a feasible and innovative digital learning resource that can support the improvement of students' understanding of bench work practice materials in vocational education.

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INTRODUCTIONS

Education serves as a fundamental means of improving human resource quality by preparing individuals to respond effectively to the evolving demands of science, technology, and the world of work. In the context of the

Industrial Revolution 4.0 and Society 5.0, vocational education is expected to develop graduates who possess not only theoretical knowledge but also practical competencies, critical thinking abilities, problem-solving skills, and adaptability to advances in digital technology (Yusmar et al., 2024). In today's world, teachers must deliver education that is both engaging and informative, ensuring that learning occurs effectively and that students can grasp the material more readily (Wijayanto et al., 2023).

Within the Mechanical Engineering Expertise Program, bench work practice is one of the fundamental competencies that Grade X students are expected to master. This competency serves as an essential foundation for machining practice, as it develops students' basic proficiency in operating various bench work equipment, including files, hand saws, scribers, hammers, vises, taps, dies, and measuring instruments. In addition, students must also understand work procedures, occupational safety and health (K3), and the correct sequence of workpiece processing before entering more complex machining competencies. If these basic competencies are not mastered properly, it will impact students' difficulties in participating in subsequent practical learning (Maulana et al., 2024).

Nevertheless, the implementation of bench work practice learning continues to encounter several challenges. Initial observations and interviews conducted with bench work practice teachers at SMK Muhammadiyah 2 Semarang revealed that many students experienced difficulties in identifying the functions of various tools, understanding the proper procedures for operating them, and comprehending the sequence of work steps prior to engaging in practical activities. When the teacher explained the worksheet, many students still paid little attention to the explanation, resulting in frequent errors in selecting tools, the sequence of work, and the technique for using the tools. This condition resulted in the practice being less effective, taking longer to complete, and students' work not meeting the expected competency standards. This lack of basic understanding can hinder students' readiness to take part in advanced practical learning and face the demands of the industrial world (Lestari & Irwansyah, 2023). These problems were influenced by several factors. One was the use of teaching materials, which were still dominated by printed modules and simple worksheets containing only text descriptions and static images. The conventional presentation of the material made students less interested in reading the material before the practice began. Furthermore, the procedural nature of bench-based practical work materials required clear visualizations so that students could understand each stage of the work coherently. If information was only conveyed through text or verbal explanations, the possibility of misconceptions would be greater (Agussintia et al., 2026).

Learning media serves an important function in enhancing the effectiveness and quality of the learning process by facilitating communication and interaction between teachers and students. According to Pagarra (in Agussintia et al, 2026), explains that learning media can present abstract concepts in a more tangible and comprehensible form, thereby supporting students in understanding instructional content. In vocational education, the effectiveness of learning is strongly influenced by the quality of practical learning implementation and the selection of appropriate instructional media (Suprayogi et al., 2024). Consequently, the selection of learning media should be aligned with the characteristics of the learning content, students' needs, instructional objectives, and the advancement of available technologies. The development of innovative learning media is therefore essential to facilitate students in comprehending practical materials more effectively while encouraging independent learning (Putri et al., 2024). The application of appropriate interactive media can further enhance the learning process, particularly when delivering practical or complex materials that require a high level of student comprehension (Swasti et al., 2022).

Recent developments in educational technology have facilitated the emergence of innovative digital learning resources, including interactive e-modules designed in a Flipbook format. Unlike conventional electronic modules, Flipbook technology integrates text, images, videos, animations, hyperlinks, and interactive assessments into a digital

book interface that can be accessed through smartphones and computers. These features facilitate independent learning and improve students' understanding of procedural materials in vocational education (Rahmat & Suherman, 2024). In addition, Flipbook media can be accessed anytime via smartphones, supporting independent learning both at school and at home (Islamiah et al., 2024).

Previous research has provided evidence of the potential of Flipbook-based learning media to support learning outcomes in vocational education. Putri and Kurniawan (2024) found that the implementation of Flipbook media contributed significantly to improving students' learning outcomes in lathe machining. Similarly, Suprayogi et al. (2024) reported that Flipbook-based e-modules were effective in enhancing students' comprehension of automotive starter system materials. Rahmagandi et al. (2024) further demonstrated that the integration of Flipbook-assisted digital modules could increase student engagement while achieving a high level of media feasibility in vocational learning. In addition, Rivai et al. (2024) emphasized that interactive Flipbook media offers practical benefits for facilitating students' independent learning, particularly through mobile device-based access. Furthermore, Syifa et al. (2024) demonstrated that Heyzine Flipbook media effectively improved students' mastery of procedural competencies by integrating multimedia demonstrations into vocational instruction. Despite these promising findings, several limitations remain. First, previous studies mainly focused on improving learning outcomes or validating learning media in different vocational subjects, with limited attention to students' procedural understanding in bench work practice. Second, most existing Flipbook-based e-modules present learning materials in a general format without comprehensively integrating procedural demonstration videos, interactive navigation, self-assessment, and smartphone-based accessibility. Third, research investigating the effectiveness of Flipbook-based interactive e-modules specifically for bench work practice in Grade X vocational schools is still scarce. These limitations indicate a research gap and highlight the need for developing a more comprehensive digital learning medium that supports students' understanding before practical workshop activities.

To overcome the identified limitations, this study proposes the development of an interactive e-module based on Flipbook technology that is specifically tailored to bench work practice materials. The novelty of the proposed e-module is reflected in the integration of procedural demonstration videos, interactive navigation features, formative assessments, self-assessment activities, and smartphone-based accessibility through the Heyzine Flipbook platform in a single learning resource. While previous studies have predominantly examined the application of Flipbook media to improve learning outcomes in other vocational subjects, the present study focuses specifically on strengthening students' procedural understanding prior to engaging in practical activities. This approach is expected to provide a more integrated and accessible digital learning resource that supports students in preparing for vocational practical work.

Building upon the identified research gap, this study seeks to develop and assess a Flipbook-based interactive e-module in terms of its validity, practicality, and effectiveness in enhancing Grade X vocational students' understanding of bench work practice materials. The results are expected to contribute to the advancement of digital learning media within vocational education by offering teachers an innovative instructional resource and supporting the implementation of the Independent Curriculum through interactive, student-centered, and technology-integrated learning. Ultimately, this study is intended to support the development of a more effective and relevant educational process that responds to the evolving demands of contemporary learning and the world of work (Sihotang et al., 2025)

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. According to Syaodih (Sari & Anggraeni., 2023) describes research and development as a systematic process intended to produce, improve, or refine an educational product. The ADDIE model was selected because it provides a structured and systematic framework for developing learning media, beginning with the identification of learning needs and continuing through the design, development, implementation, and evaluation of the resulting product (Pagarra in Agussintia et al., 2022).

The research was conducted at SMK Muhammadiyah 2 Semarang, Indonesia, during the 2025/2026 academic year. The study involved 50 Grade X students enrolled in the Mechanical Engineering Expertise Program. Participants were selected through purposive sampling based on several considerations, including the similarity of students' academic backgrounds, the use of the same curriculum, instruction by the same subject teacher, and comparable learning facilities across the classes. The participants were divided into two groups, with 25 students assigned to the experimental class and 25 students to the control class. The experimental group received instruction using the Flipbook-based interactive e-module, whereas the control group was taught using the conventional instructional materials provided by the school. The determination of the experimental and control groups was carried out in consultation with the subject teacher to ensure comparable initial learning abilities and minimize potential differences in classroom conditions.

The Analysis stage was carried out by observing the learning process, conducting interviews with subject teachers, and reviewing relevant instructional documents, including Learning Outcomes (CP), Learning Objective Flow (ATP), teaching modules, and learning materials implemented at the school. This stage was intended to identify students' learning needs, examine the characteristics of the subject matter, and determine the problems encountered during bench work practice learning. The Design stage focused on planning the structure and components of the learning product. This included organizing the instructional content, developing assessment instruments, designing the user interface, and determining appropriate supporting media, such as images, instructional videos, animations, and interactive assessment activities. The content and learning activities were systematically developed in accordance with the Learning Outcomes of the Independent Curriculum for Phase E of the Mechanical Engineering Expertise Program.

The Development stage focused on producing the e-module using document authoring software, which was subsequently transformed into a digital learning resource in the form of a Heyzine Flipbook that could be accessed through computers and smartphones. The resulting e-module was evaluated by subject matter experts, media experts, and assessment experts to determine its validity and obtain recommendations for improvement. The validity of the learning media was determined by calculating the percentage of feasibility based on the scores provided by the validators. Prior to classroom implementation, the e-module was revised according to expert feedback to ensure that the final product met the required quality standards. The Implementation stage involved conducting a trial of the developed e-module with Grade X students in the Mechanical Engineering Expertise Program. Students utilized the e-module as a learning resource to prepare for practical activities. Following the trial, both teachers and students completed practicality questionnaires covering aspects such as ease of use, visual presentation, content delivery, and the usefulness of the media in supporting the learning process.

The Evaluation stage represents the final step of the ADDIE model and is conducted to determine the overall quality of the developed e-module in terms of validity, practicality, and effectiveness. The effectiveness of the e-module was evaluated by administering a pretest prior to the learning activities and a posttest after students had

completed the learning process using the developed e-module. The extent of improvement in students' understanding was subsequently determined by calculating the N-Gain score.

Research Instruments and Validation

This study utilized four research instruments, namely expert validation forms, teacher response questionnaires, student response questionnaires, and pretest–posttest assessments. The expert validation instruments were used to examine the developed e-module in terms of content quality, instructional presentation, language, media design, and assessment components. Meanwhile, the teacher and student response questionnaires were administered to evaluate the practicality of the e-module, including its ease of use, visual appeal, learning efficiency, and usefulness in supporting the learning process. The pretest and posttest were conducted to assess students' understanding of bench work practice materials before and after the implementation of the developed e-module.

The developed e-module underwent validation by five experts, comprising two media experts, two subject matter experts, and one assessment expert. The media experts evaluated various aspects of the e-module, including interface design, navigation, typography, readability, multimedia integration, and overall usability. Meanwhile, the subject matter experts assessed the alignment of the content with the curriculum, accuracy and completeness of the material, organization of instructional content, and formulation of learning objectives. The assessment experts evaluated the suitability of evaluation instruments, question construction, scoring criteria, language clarity, and alignment between learning objectives and assessment indicators. Each validator independently reviewed the product using a five-point Likert scale and provided qualitative suggestions for improvement. The e-module and research instruments were subsequently revised based on the validators' recommendations before classroom implementation.

Data analysis techniques

The data obtained in this study were analyzed using both descriptive and inferential statistical methods. The validity and practicality of the developed e-module were evaluated through descriptive percentage analysis, with the calculation performed using the following formula:

$$P = \frac{\sum X}{\sum X_i} \times 100\%$$

In this analysis, P denotes the percentage of the obtained score, $\sum X$ refers to the total score achieved, and $\sum X_i$ indicates the maximum attainable score. The resulting percentages were interpreted according to the following classification: 80–100% was categorized as Very Valid/Very Practical; 60–80% as Valid/Practical; 40–60% as Fairly Valid/Fairly Practical; 20–40% as Less Valid/Less Practical; and 0–20% as Invalid/Impractical. The overall validity score for each assessed aspect was determined by calculating the mean score obtained from the two validators.

The effectiveness of the developed e-module was determined by comparing students' pretest and posttest results. Before conducting the hypothesis test, the data were examined for normality using the Shapiro–Wilk test and for homogeneity using Levene's test. The results indicated that the data met both statistical assumptions, as shown by $p > 0.05$. Therefore, a paired-sample t -test was subsequently applied to examine whether the use of the developed e-module resulted in a statistically significant improvement in students' understanding. The magnitude of learning improvement was determined using the Normalized Gain (N-Gain) formula:

$$N-Gain = \frac{\text{Posttest} - \text{Pretest}}{\text{Maximum Score} - \text{Pretest}}$$

The N-Gain scores were classified into three categories: High (≥ 0.70), Moderate (0.30–0.69), and Low (< 0.30). All statistical procedures were conducted using IBM SPSS Statistics version 26, with the significance level set at 0.05.

Before the research was conducted, formal permission was obtained from the Principal of SMK Muhammadiyah 2 Semarang and the Head of the Mechanical Engineering Expertise Program. The research activities were subsequently coordinated with the relevant subject teacher to ensure the smooth implementation of the study. Participation was voluntary, and the participants were provided with information regarding the purpose and procedures of the research. To protect participants' privacy, students' identities and research data were kept confidential throughout the study. All data collected during the research were used exclusively for academic and research purposes.

RESULT AND DISCUSSION

Result

This research and development study produced an interactive digital Flipbook teaching material developed using the Heyzine platform for Grade X bench work practice materials. The study was conducted at SMK Muhammadiyah 2 Semarang and employed the ADDIE development model. This model consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. Each stage was carried out sequentially to guide the development and assessment of the learning product. The following section presents a detailed description of each stage.

Analyze

In this initial stage, the researcher analyzed the needs and problems encountered in learning for grade X students of SMK Muhammadiyah 2 Semarang. The researcher conducted the analysis by interviewing the teacher of the subject of bench work. Based on interviews conducted with the Indonesian language teacher at SMK Muhammadiyah 2 Semarang, the school has implemented the Independent Curriculum. The interview findings revealed that students did not have a dedicated textbook or learning guide for bench work practice. Instead, they primarily obtained learning materials from internet sources and relied on explanations delivered by the teacher. This learning condition tended to reduce students' attention and interest, as the available materials were considered less engaging and could cause students to become bored or less motivated during the learning process. These conditions indicated the need for innovation in learning materials by utilizing advances in educational technology.

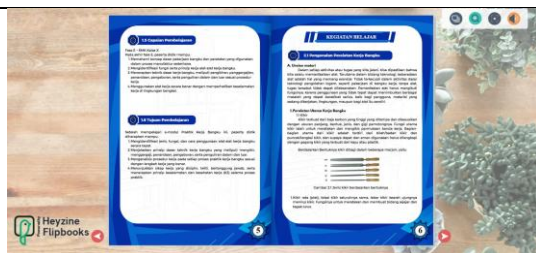
Furthermore, the analysis showed that the learning materials currently used had limited interactive and varied features. At the same time, students were already familiar with using smartphones in their daily activities. This situation presented an opportunity to integrate mobile-accessible digital technology into the learning process. Therefore, the findings from the Analysis stage provided a basis for developing an interactive Flipbook-based e-module that offers more engaging learning materials and supports students in developing a better understanding of bench work practice.

Design

The next stage is the design stage. Several steps are taken in this stage, including determining learning outcomes and objectives, collecting materials, images, and videos, selecting a format, drafting the product to be developed, and creating research instruments.

Table 1 Flipbook-based E-Module design on bench work practice material

Design	Information
	Cover design of the interactive Flipbook-based e-module developed for Grade X bench work practice materials.
Design	Information
	Table of contents interface of the interactive e-module.
	Guidelines for using the Flipbook-based interactive e-module.



Presentation of bench work practice materials within the Flipbook-based interactive e-module.

Source: Design Draft, 2026

Development

After the design stage, the researcher began developing the draft into an interactive digital flipbook teaching material product using Heyzine containing bench work materials. The development was carried out using the Canva application according to the previously prepared design. After the digital teaching material design was completed using the Canva application, the product was downloaded in PDF format. Then the PDF file was converted into the Heyzine website. On the Heyzine website, the researcher developed teaching materials by adding previously prepared videos and images, and utilizing the features provided by the Heyzine website to make the teaching materials interactive, such as adding search links, links that when clicked can move pages, videos that can be played in the teaching materials by students, adding background, and others. After the e-module had been fully developed, a product validation process was conducted involving media experts, subject matter experts, and assessment experts to determine its suitability for use in the learning process.

The validity of the Flipbook-based e-module was assessed by media, subject matter, and assessment experts using evaluation indicators developed in accordance with established feasibility standards. This validation was conducted to examine the quality and appropriateness of the developed learning resource prior to its implementation in the study. A Likert scale was employed to assess each indicator, with the resulting scores converted into percentages for each validation category, as presented in Table 2.

Table 2 Validity test result criteria

Validity Percentage	Criteria
$80\% < V \leq 100\%$	Very Valid
$60\% < V \leq 80\%$	Valid
$40\% < V \leq 60\%$	Quite Valid
$20\% < V \leq 40\%$	Less valid
$0\% < V \leq 20\%$	Invalid

Source : Riduwan (in Nurfadillah, 2025)

The detailed results of the validation process are provided in Table 3.

Table 3 Validity test results

Validation	Average percentage 100%	Criteria
Media Expert	87.79%	Very Valid
Subject Matter Expert	84.9%	Very Valid
Question Expert	89.95%	Very Valid

Source: Validity Test, 2026

As presented in Table 3, the validation assessment yielded scores of 87.79% for the learning media, 84.90% for the developed learning materials, and 89.95% for the pretest and posttest instruments. These findings demonstrate that the learning media developed through the ADDIE model achieved a high level of validity and met the established feasibility criteria. Therefore, the developed e-module was considered suitable for use in the subsequent research implementation.

The validation findings demonstrate that the developed Flipbook-based interactive e-module achieved a high level of feasibility for implementation in classroom learning. The favorable scores obtained from the media, subject matter, and assessment experts indicate that the product meets key quality requirements, including content accuracy, instructional structure, visual and interface design, language clarity, and the appropriateness of the assessment components. These findings suggest that integrating multimedia components such as illustrations, embedded demonstration videos, hyperlinks, and interactive navigation enhances the quality of instructional media for vocational education. Similar findings were reported by Putri and Kurniawan (2024), who found that Flipbook-based learning media significantly improved the quality of machining instruction through more attractive and interactive learning resources. Likewise, Maulana et al. (2024) concluded that Flipbook-based e-modules fulfilled the criteria of valid instructional media because they effectively combined curriculum-oriented content with multimedia features that facilitated independent learning.

Implementation

The study was conducted at SMK Muhammadiyah 2 Semarang and involved two groups of Grade X students. The experimental group consisted of 25 students from Class X TO3, while the control group comprised 25 students from Class X TO4. The research procedure began with the administration of a pretest to both groups to determine their initial level of understanding. Subsequently, students in the experimental group were introduced to the web-based learning media developed using the ADDIE model and were given an opportunity to explore and use the media independently during the learning process. After the instructional activities were completed, both the experimental and control groups were administered a posttest to measure students' understanding and determine the improvement achieved in the bench work practice material.

Evaluation

Researchers conducted a practicality test of the media through teacher and student responses to the flipbook-based e-module for classroom work. The practicality assessment employed a Likert scale to obtain percentage scores, which were subsequently classified according to predetermined categories, as presented in Table 4.

Table 4 Practicality test results criteria

Validity Percentage	Criteria
80% < V ≤ 100%	Very Practical
60% < V ≤ 80%	Practical
40% < V ≤ 60%	Quite Practical
20% < V ≤ 40%	Less practical
0% < V ≤ 20%	Impractical

Source : Rahmawati, 2017

The detailed findings of the practicality assessment are presented in Table 5.

Table 5 Practicality test results

Aspect	Teacher	Student
Ease of Use	90%	89.8%
Attractiveness	82.5%	87%
Practicality	90%	90.8%
Efficiency	95%	86.8%
Total	89.38%	88.62%

Source: Practicality Test, 2026

As shown in Table 5, the practicality assessment based on the subject teacher's response yielded a score of 89.38%, while the responses from 25 students resulted in a score of 88.62%. These findings indicate that the learning media developed using the ADDIE model falls within the very practical category. Thus, the Flipbook-based interactive e-module is considered practical and suitable for implementation in the learning process.

The high practicality scores suggest that both teachers and students regarded the developed e-module as easy to operate, visually appealing, and useful in supporting the learning process. The integration of multimedia features within the Flipbook platform, such as interactive navigation, visual illustrations, and embedded instructional videos, appears to have enhanced students' engagement with the learning materials. These results are consistent with Islamiah et al. (2024), who reported that Flipbook-based learning media increased students' learning motivation and facilitated independent learning through interactive digital content. Similarly, Yusmar et al, (2024) reported that Flipbook-based e-modules supported by external multimedia features improved usability and encouraged students to engage in self-directed learning. In comparison with previous studies, the e-module developed in the present study offers a more comprehensive learning resource by incorporating procedural demonstrations specifically designed to support students in understanding bench work practice activities.

The effectiveness of the Flipbook-based interactive e-module for bench work practice materials was evaluated by comparing the pretest and posttest results of students in the experimental and control groups. Before conducting the effectiveness analysis, prerequisite tests, including normality and homogeneity tests, were performed. The normality test was conducted to determine whether the pretest and posttest data were normally distributed. The normality analysis was performed using the Shapiro–Wilk test with IBM SPSS Statistics version 26. The results of the normality test are presented below.

Table 6 Normality test results using the Shapiro-Wilk test

	Class	Statistics	Shapiro-Wilk	
			df	Sig.
Results	Pretest A (Control)	.942	25	.165
	Posttest A (Control)	.944	25	.181
	Pretest B (Experiment)	.962	25	.446
	Posttest B (Experiment)	.934	25	.106

Source: SPSS Output, 2026

As shown in Table 6, the Shapiro–Wilk normality test produced significance values of 0.165 and 0.181 for the pretest and posttest data, respectively, in the control group. Meanwhile, the experimental group obtained significance values of 0.446 for the pretest and 0.106 for the posttest. Since all significance values were greater than 0.05, the pretest and posttest data for both groups were considered normally distributed. These results confirm that the normality assumption was satisfied, allowing the analysis to proceed to the homogeneity test.

The homogeneity test was performed to determine whether the variances of the data obtained from the analyzed groups were homogeneous. The test was conducted using Levene's test in IBM SPSS Statistics version 26.

Table 7 Levene's Test Results for Homogeneity of Variance

		Levene Statistics	df1	df2	Sig.
Learning outcomes	Based on Mean	.737	1	48	.395
	Based on Median	.913	1	48	.344
	Based on Median and with adjusted df	.913	1	47,229	.344
	Based on trimmed mean	.696	1	48	.408

Source: SPSS Output, 2026

As presented in Table 7, the Levene's test yielded a significance value of 0.395. Since this value is greater than 0.05, the data were considered homogeneous, indicating that the homogeneity of variance assumption was satisfied.

After confirming that the data met the assumptions of normality and homogeneity, the analysis proceeded to hypothesis testing using a paired sample *t*-test. This test was applied to determine whether there was a statistically significant difference between students' pretest and posttest scores following the learning intervention. The results of the paired sample *t*-test obtained using IBM SPSS Statistics version 26 are presented below.

Table 8 Paired Sample T-test Results

		Paired Differences							
		95% Confidence Interval of the Difference							
		Mean	Std. Deviaton	Std. Error Mean	Lower	Upper	t	df	Sig.(2-tailed)
Pair 1	Pretest - Posttest	-25.960	6.907	1.381	-28.811	-23.109	-18.793	24	.000

Source : Output SPSS,2026

As shown in Table 8, the paired sample *t*-test resulted in a two-tailed significance value of 0.000. Since the obtained significance value was below 0.05, a statistically significant difference was identified between the pretest and posttest scores. This finding indicates that the Flipbook-based interactive e-module had a significant positive effect on students' understanding of bench work practice materials. The improvement may be attributed to the

integration of multimedia components that allow students to repeatedly access and observe procedural demonstrations before carrying out practical activities. This finding is consistent with Suprayogi et al. (2024), who reported that Flipbook Maker-based e-modules significantly improved students' understanding of automotive starter system materials. Likewise, Wahyu Wijayanto et al. (2023) found that Flipbook-based e-modules enhanced students' conceptual understanding by providing multimedia-based learning experiences that were more meaningful than conventional printed materials.

N-Gain analysis was conducted using the pretest and posttest scores to determine the extent of improvement in students' understanding in both the experimental and control groups. The N-Gain score was also used to evaluate the effectiveness of the developed Flipbook-based interactive e-module in improving students' understanding following the learning intervention.

The effectiveness levels based on the N-Gain scores were classified according to the criteria presented in Table 9.

Table 9 N-Gain score effectiveness interpretation category

N-gain Score (g) (%)	Criteria
$\% \geq 76$	Effective
$56 \leq \% < 76$	Quite Effective
$40 \leq \% < 56$	Less Effective
$\% < 40$	Ineffective

Source: Ismiati, 2023

The results of the N-Gain score test can be seen in table 10.

Table 10 N-Gain score test results

Statistics	N-Gain	
	Control Class (without e-module)	Experimental Class (with e-module)
Minimum N-Gain	11	39
Maximum N-Gain	47	93
Average	27.81	65.23
Standard deviation	12,288	11,216
Variance	125,798	150,988

Source: SPSS Output, 2026

Based on the N-Gain score calculations presented in Table 10, the control group obtained an average N-Gain score of 27.81%, which was classified as ineffective. In contrast, the experimental group achieved an average N-Gain score of 65.23%, falling into the moderately effective category. These results indicate that the implementation of the Flipbook-based interactive e-module for bench work practice materials was moderately effective in improving the understanding of Grade X students at SMK Muhammadiyah 2 Semarang.

The higher N-Gain score achieved by the experimental group compared with the control group demonstrates the greater improvement associated with the use of the developed e-module. The integration of multimedia components, procedural demonstration videos, self-evaluation activities, and mobile accessibility provided students with opportunities to study the material independently and repeatedly before conducting practical activities in the workshop. This finding is in line with Sihotang et al. (2025), who stated that interactive digital learning media can

promote student engagement and support innovative learning practices in the digital era. Furthermore, Satriani and Pryanti (2024) reported that the Heyzine Flipbook platform offers accessibility and flexibility, enabling students to access learning materials anytime and anywhere.

Discussion

Overall, the findings indicate that the developed Flipbook-based interactive e-module meets the three essential criteria for a quality educational product: validity, practicality, and effectiveness. The high validation scores demonstrate that the e-module is appropriate in terms of content quality, instructional structure, media design, and assessment components. Meanwhile, the favorable practicality results reflect positive acceptance from both teachers and students, particularly regarding the e-module's usability, accessibility, and interactive features. In addition, the significant increase in students' understanding provides evidence that the integration of multimedia elements can effectively support the acquisition of procedural knowledge in vocational learning.

Compared with previous studies, this research provides several important contributions. Earlier studies primarily developed Flipbook media for machining, entrepreneurship, electrical installation, or automotive systems (Putri & Kurniawan, 2024; Suprayogi et al., 2024; Maulana et al., 2024). In contrast, this study specifically focuses on bench work practice, which requires students to master procedural knowledge before conducting practical activities. Moreover, unlike previous studies, the developed e-module integrates demonstration videos, interactive navigation, formative assessments, self-evaluation, and smartphone accessibility through the Heyzine platform within a single instructional medium. These integrated features represent the novelty of this research and provide a more comprehensive digital learning solution for vocational education.

The findings of this study offer several practical implications for vocational education. The developed Flipbook-based interactive e-module can be utilized as an alternative digital learning resource to support student-centered instruction and independent learning. Through the integration of multimedia elements, procedural demonstration videos, and interactive assessments, the e-module provides students with opportunities to review and understand bench work procedures before engaging in workshop activities. This may help minimize procedural errors and improve students' preparedness for practical learning. Furthermore, the developed e-module contributes to the implementation of the Independent Curriculum by encouraging the integration of digital technology into vocational learning.

Despite these contributions, this study has several limitations. First, the research was conducted at only one vocational school and involved a relatively limited number of participants, which may restrict the generalizability of the findings to other educational contexts. Second, the effectiveness assessment primarily examined short-term changes in students' understanding following the implementation of the e-module. Future research should consider involving larger and more diverse samples, examining long-term retention of learning, and investigating the effectiveness of Flipbook-based interactive e-modules in improving students' practical competencies and performance during workshop activities.

CONCLUSION

This study successfully developed a Flipbook-based interactive e-module for Grade X vocational students focusing on bench work practice materials through the ADDIE development model. The resulting e-module met the established criteria for validity, practicality, and effectiveness, demonstrating its suitability as a digital learning resource for supporting vocational education. The implementation findings further revealed that students who

utilized the developed e-module achieved a significantly greater improvement in understanding compared with those who received instruction using conventional learning materials.

The novelty of this study lies in the integration of procedural demonstration videos, interactive navigation, formative assessments, self-evaluation, and smartphone accessibility through the Heyzine Flipbook platform within a single learning resource specifically designed for bench work practice. These integrated features enable students to study procedural concepts independently before conducting workshop activities, thereby enhancing their understanding and learning readiness.

The findings of this study contribute to the advancement of technology-enhanced learning media in vocational education by introducing an innovative digital learning resource that supports the implementation of the Independent Curriculum. The Flipbook-based e-module facilitates a more interactive, flexible, and student-centered learning experience. Future research should involve larger and more heterogeneous samples across multiple vocational schools to strengthen the generalizability of the findings. Further studies are also encouraged to examine the long-term effects of the e-module on students' practical competencies and explore the integration of emerging technologies, such as adaptive learning systems and artificial intelligence, to enhance the effectiveness of digital learning in vocational education.

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