Sosioedukasi
JURNAL ILMIAH ILMU PENDIDIKAN DAN SOSIAL
ISSN: 2086-6135 E-ISSN: 2541-612x
Volume 15 No. 2. June 2026 https://ejournal.unibabwi.ac.id/index.php/sosioedukasi/index

LEARNING USING FLIPBOOK-BASED E-MODULES TO IMPROVE LEARNING OUTCOMES OF UNDERSTANDING THE FUNCTION OF MACHINE PARTS FOR STUDENTS OF THE MACHINING ENGINEERING EXPERTISE PROGRAM CLASS XI SMK NEGERI 1 KARANGAWEN

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ARTICLE HISTORY
Received : 20-04-2026
Revised : 07-05-2026
Accepted : 15-06-2026

KEYWORDS
Flipbook e-Modules;
Learning Outcomes;
Milling Machines Parts;
Vocational Education;
Educational Technology;

ABSTRACT
This study aims to analyze the effectiveness of the use of flipbook-based e-modules in improving student learning outcomes in the material of understanding the function of milling machine parts in the Machining Engineering Expertise Program of SMK Negeri 1 Karangawen. The study employed a nonequivalent control group design and a quantitative, quasi-experimental methodology. Twenty-five students from the experimental class and twenty-five from the control class made up the research sample. Data were collected through expert validation and learning outcome tests. N-Gain analysis revealed that the experimental class had an average increase in learning outcomes of 85.64% in the high category, compared to 45.14% in the medium category for the control class. These findings suggest that using flipbook-based e-modules can enhance students' comprehension and learning outcomes about the functional content of the milling machine's components.

INTRODUCTION

In Indonesia, vocational education plays a crucial role in producing human resources who are capable, skilled, and prepared to operate in accordance with the demands of the commercial and industrial world, particularly at the Vocational High School level. Vocational High Schools as the main organizer of vocational education, play an important role in producing a skilled workforce that is ready to compete in the industry (Agustian et al., 2024). One of the essential competencies in the Machining Engineering Expertise Program is understanding the functions of milling machine parts, as this knowledge enables students to operate machines correctly, work efficiently, and apply occupational safety procedures during practice. Insufficient understanding of machine components may lead to

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operational errors, lower work quality, and increased risk of workplace accidents. This is in line with the findings of the study M. Hasanuddin et al., (2024) which states that students' lack of understanding of machine use and occupational safety (K3) leads to potential errors in the operation of tools as well as an increased risk of work accidents in the practical workshop environment. Therefore, in order to effectively acquire the desired competences, the learning process in vocational education must be supported by learning methodologies and media that may maximize students' conceptual knowledge and abilities.

According to preliminary findings at SMK Negeri 1 Karangawen, grade XI students in the Machining Engineering expertise program continue to have comparatively inadequate learning results in the functional material of new machine parts. Similar issues in Milling Machining Theory learning were reported by Widiyanti et al., (2023), where the limited use of instructional media, such as PowerPoint presentations and learning videos, led to difficulties in students' understanding of the material and reduced their interest in learning. In line with Fauzan & Rahdiyanta, (2017), it was also said that one of the teachers of the theory of mechanical engineering also said that students had difficulty in understanding the theory, so it took a long time to deliver the material and learning media was needed. Low conceptual understanding affects both cognitive achievement and practical skills, as reflected in the fact that many students have not yet met the minimum competency standards established by the school. This situation demonstrates the necessity of improving the learning process using the application of more creative learning techniques as well as the application of educational materials that may maximize student comprehension and engagement.

Learning outcomes reflect students' abilities and knowledge as a consequence of the learning process undertaken (Wandi & Erizon, 2023). Students' low learning outcomes are partly attributed to traditional teacher-centered instruction that relies heavily on lectures and printed textbooks. This is in line with research H. Hasanuddin et al., (2023) that states that teachers deliver material still using the lecture method and students only rely on teaching modules which are only in the form of jobsheets for learning resources. As a result, students tend to be passive, particularly when learning technical and abstract concepts such as the functions of milling machine parts, which require adequate visualization for effective understanding. Therefore, vocational students require visual, contextual, and interactive learning experiences to better understand and apply the material in machining practices. In order to improve student engagement and comprehension of the course materials, innovation in the learning process is thus required through the use of more engaging media and in line with the characteristics of vocational education.

The advancement of information and communication technology in education provides opportunities to develop more effective and interactive learning media, particularly in vocational education. One such innovation is the flipbook-based e-module, a digital teaching material designed to support both guided and independent learning. The benefit of e-modules itself is to provide solutions for educators and students to be able to take advantage of the sophistication of communication and information technology wisely for learning purposes in the world of Education (H. Hasanuddin et al., 2023). Flipbook-based e-modules integrate multimedia features such as images, animations, videos, audio, and interactive assessments, making learning materials more engaging, accessible, and easier to understand. The research Sa'diyah, (2021) also stated that Digital flipbook-based E-modules are an ingenious approach to enhance students' comprehension of the subject matter and provide an engaging, interactive learning environment. In machining engineering education, where many concepts related to machine components and mechanisms require strong visualization, flipbook-based e-modules can help students understand material more concretely while supporting self-paced learning. Therefore, their implementation is expected to improve students' motivation, understanding, and learning outcomes.

Several studies have demonstrated the potential of flipbook-based e-modules in vocational education. Rahmagandi et al., (2024) reported that the implementation of a flipbook-based e-module in manufacturing design learning improved students' learning outcomes and engagement. Similarly, Muhammad Hudan Rahmat & Harie Satiyadi Jaya, (2020) developed a flipbook-based e-module learning and found that the media was feasible and effective in supporting the learning process. However, these studies mainly focused on media development and implementation in different vocational subjects. Research specifically examining the effectiveness of flipbook-based

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e-modules in improving students' understanding of the functions of milling machine parts remains limited. Therefore, this study investigates the effectiveness of a flipbook-based e-module that integrates technical visualizations of milling machine components and their working relationships to improve students' learning outcomes through a quasi-experimental approach.

METHOD

Research Design

This study employed a quantitative approach using quasi-experimental design. Two groups—the experimental group and the control group—are involved in the nonequivalent control group study design that was used. To determine the students' initial competence, a pretest was administered to both groups. Additionally, while the control group got traditional instruction, the experimental group was treated with flipbook-based e-modules. Following the completion of the learning process, a posttest was administered to both groups in order to determine the students' learning results following the therapy.

Table 1 Research Design

Groups	Pretest	Treatment	Posttest
Experiment	O	X	O
Control	O	-	O

Source: Maulidah et al., (2020)

Research Subject and Location

This research was carried out at SMK Negeri 1 Karangawen in grade XI students of the Machining Engineering Expertise Program. The research sample consisted of two classes, namely class XI TP 1 as a control class with 25 students and class XI TP 2 as an experimental class with 25 students. Saturated sampling, which determines the sample by employing the complete population as a study sample, was the sampling method employed.

Research Procedure

The research procedure was conducted through three sequential stages, namely the preparation stage, the implementation stage, and the final stage. In the preparation stage, an initial observation was carried out at SMK Negeri 1 Karangawen to identify existing learning conditions and determine the problems faced by students in learning the functions of milling machine parts. Based on the results of the observation, a flipbook-based e-module was designed and developed as the learning media. In addition, research instruments consisting of learning outcome tests and observation sheets were prepared. Before being implemented, both the learning media and the instruments underwent validation by media experts and subject-matter experts to ensure their suitability and feasibility. After obtaining validation results, two classes were designated as research participants, with Class XI TP 2 serving as the experimental group and Class XI TP 1 serving as the control group.

The implementation stage was conducted in three meetings. During the first meeting, students in both groups completed a pretest to assess their prior knowledge of the learning material. The second meeting was devoted to the treatment phase. Students in the experimental class participated in learning activities using the flipbook-based e-module, which presented the material through digital content supported by visual elements and interactive features. Throughout the lesson, students were encouraged to explore the material independently while receiving guidance from the teacher when necessary. In contrast, students in the control class learned through the lecture method that is routinely applied in classroom instruction. In this setting, the teacher delivered explanations directly, while students listened, took notes, and engaged in question-and-answer activities. To minimize the influence of external factors, both classes were taught by the same teacher, covered identical learning content, followed the same learning objectives, and received an equal amount of instructional time. The third meeting was used to administer a posttest to both groups in order to measure students' learning achievement after the instructional treatment had been completed.

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The final stage focused on data processing and analysis. All research data, including pretest scores, posttest scores, observation records, and supporting documentation, were collected and organized systematically. Subsequently, the data were analyzed using descriptive statistical techniques, normality testing, homogeneity testing, independent sample t-test analysis, and N-Gain analysis. The outcomes of these analyses were then interpreted to evaluate the effectiveness of the flipbook-based e-module in enhancing students' learning outcomes. Finally, the findings were compiled into a research report and used as the basis for drawing conclusions aligned with the objectives of the study.

Data Collection Techniques

In order to get comprehensive data and support the accomplishment of research objectives, the data collecting procedure in this study is conducted using several methodologies. In order to evaluate the viability of flipbook-based e-modules in terms of appearance, design, navigation, readability, and simplicity of use in the learning process, data gathering started with validation by media specialists. Additionally, the validation of material experts is performed to make sure that the content is appropriate for learning competencies, that the concepts are accurate, that the material is deep, and that it is relevant to the needs of students in terms of their ability to comprehend the functions of the milling machine's parts. In addition, expert validation of test questions is used to assess the feasibility of the evaluation instrument, including the suitability of indicators, clarity of question items, and the ability of questions to accurately measure learning outcomes.

In addition to the validation process, data collection is also carried out through observation during learning activities. This observation aims to obtain information about student activities and involvement, as well as the implementation of the use of flipbook-based e-modules in the classroom. Furthermore, learning outcome tests are given in the form of pretest and posttest to determine the improvement of students' abilities after the implementation of the developed learning media. Documentation techniques are also used as supporting data, in the form of photos of research activities, learning tools, validation results, and various other documents relevant to the implementation of research. It is intended that by utilizing these several approaches, the data collected will be reliable, impartial, and capable of supporting the examination of how well flipbook-based e-modules affect student learning results.

Research Instruments

The research instruments used in this study consisted of flipbook-based e-modules and learning outcome test questions. The e-module is used as a learning medium for understanding the function of milling machine parts for students of the Mechanical Engineering Expertise Program in grade XI of SMK Negeri 1 Karangawen. The e-module contains learning materials, supporting pictures and illustrations, learning videos, instructions for use, learning objectives, and learning evaluations that are systematically compiled to make it easier for students to understand the material independently and during the learning process.

In addition to flipbook-based e-modules, learning outcome test questions administered as a pretest and posttest are utilized as research instruments to assess students' initial proficiency and growth in learning outcomes following their participation in the learning process. A number of factors are taken into consideration when creating test questions based on learning indicators of machining materials. These factors include the questions' appropriateness in relation to the learning indicators, the accuracy of the answers, the formulation of brief questions, the use of sentences devoid of negative statements, the use of clear and understandable language, and the accuracy of sentence writing. Test questions must thus be able to evaluate student learning outcomes in a way that is both objective and consistent with the established learning objectives.

Validity and Reliability Tests

Content validity or focus content validity provides evidence on the elements present in the measurement tool and is processed by rational analysis (Febrianawati, 2018). Validation of research instruments is carried out on e-module instruments and test question instruments before being used in research. E-module validation consists of validation of the completeness of the e-module by media experts and validation of the content of the material by material experts. In the validation of the completeness of the e-module, the aspects assessed include the existence of the cover, foreword, table of contents, instructions for use, learning objectives, learning materials, supporting images

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or illustrations, learning videos, final evaluation, and bibliography. Meanwhile, the validation of the e-module material includes the suitability and completeness of material about the components and parts of the milling machine, such as arbor, tool holder or collet, ragum, clamp set, divider head, turntable, base, column, knee, saddle, table, spindle, overarm, feeding system, speed system, and cooling system. The assessment was carried out using a dichotomy scale with the options "YES" and "NO". The validity test of the e-module instrument was analyzed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) to determine the level of suitability of each item based on the assessment of experts. The Content Validity Ratio (CVR) is used to assess the level of agreement among experts on the importance of an item in a research instrument. The CVR value is calculated based on a comparison between the number of experts who declared the item essential or according to the number of all experts involved in the validation process. By involving five expert validators, an item is declared valid if it has a minimum CVR value of 1.00 with the help of Microsoft Excel software. Furthermore, the Content Validity Index (CVI) is calculated based on the average of all eligible CVR values so that it can be used to determine the level of validity of the overall content of the instrument. The CVI value range of 0.78–1.00 is categorized as very appropriate or very suitable for use with the help of Microsoft Excel software. The instrument is declared valid if the CVR and CVI values meet the specified validity criteria. Furthermore, the reliability of the instrument was analyzed using Percentage of Agreement (PA) to determine the level of agreement between validators with the help of Microsoft Excel software. The instrument is declared reliable if the PA value ≥ 75%, which indicates the consistency of the assessment between validators. The high and low reliability is empirically shown by a number called the reliability coefficient value, empirically shown by a number called the reliability coefficient value (Pramuaji & Loekmono, 2018).

The validation of the test question instrument is carried out by question experts by assessing several aspects, namely the suitability of the questions with learning indicators, the accuracy of the answers, the clarity of the question formulation, the use of language, and the accuracy of sentence writing. The validity test of the test question instrument was analyzed using the V Aiken approach to determine the level of validity of the content of each question item based on expert assessment with the help of Microsoft Excel software. The question item is declared valid if it obtains a V Aiken value in accordance with the validity category used. Furthermore, the reliability test of the test question instrument was analyzed using the Intraclass Correlation Coefficient (ICC) to determine the level of consistency of the assessment between validators with the help of IBM SPSS Statistic 25 software. The question instrument is declared reliable if the ICC value shows a good or very good reliability category.

Data Analysis Techniques

Data analysis is the act of locating and organizing information in a systematic way using information from documents, observations, interviews, and records in order to improve a researcher's comprehension of the subject under study and provide results to others (Qomaruddin & Sa'diyah, 2024). Pretest and posttest results from both the experimental and control groups are used in this study's data analysis technique. Using IBM SPSS Statistics 25 software, the first step of analysis was descriptive analysis to characterize characteristics of the study data, such as the average value, maximum value, minimum value, and standard deviation in each group.

In the use of parametric and nonparametric statistical tests, it is necessary to carry out the analysis requirements test (Sianturi, 2022). A homogeneity test and a normality test were the required tests that were performed. Using Shapiro-Wilk with a significance threshold of 0.05, the normality test was utilized to ascertain whether or not the pretest and posttest data were regularly distributed. If the significance value (Sig.) is more than 0.05, the data is considered to be normaly distributed. The comparability of variance between the experimental class and the control class was then assessed using a homogeneity test. This test uses the Levene Test with the criteria of data being declared homogeneous if the significance value (Sig.) > 0.05, which is also analyzed using IBM SPSS Statistics 25.

An independent sample t-test is used to assess the difference in learning outcomes between the experimental class and the control class if all required tests are passed. The hypothesis was accepted if the Sig. (2-tailed) value was less than 0.05, which would indicate a significant difference in learning outcomes between the two groups. This test was carried out at a significance level of 0.05.

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Additionally, this study measured the improvement in student learning outcomes following the administration of the medication using N-Gain analysis. Each student's pretest and posttest results were compared to calculate N-Gain, which was then divided into three categories: high (N-Gain > 0.70), medium (0.30 ≤ N-Gain ≤ 0.70), and low (N-Gain < 0.30). Using IBM SPSS Statistics 25, this investigation evaluated how well flipbook-based e-modules improved student learning outcomes.

RESULT AND DISCUSSION

Research Results

The impact of using flipbook-based e-modules on students' learning outcomes in the material of comprehending the function of new machine parts in the Machining Engineering Expertise Program class XI is examined in this study. The instrument, which consists of e-modules and test questions, is first validated by an expert validator before being used in research. This process evaluates the instrument's viability, including the e-module's completeness, the material content's appropriateness, and the question items' compatibility with the learning indicators. Research data was obtained through the implementation of pretest and posttest in the experimental class and the control class. In order to ascertain the difference and enhancement of student learning outcomes following treatment, the data was further examined using descriptive analysis, normality test, homogeneity test, independent sample t-test, and N-Gain analysis. In addition to test data, observation results during the learning process are also used as supporting data to see the implementation of the use of flipbook-based e-modules in classroom learning activities. The results of the analysis are then used to answer the research objectives and provide interpretation of the findings obtained during the research process.

CVR CVI and Percentage Agreement Media Expert

Table 1 Media Expert Ratings

Assessment Aspects	V1	V2	V3	V4	V5	V6	Ne	CVR	CVI
Item 1	1	1	1	1	1	1	6	1,00	1,00
Item 2	1	1	1	1	1	1	6	1,00	1,00
Item 3	1	1	1	1	1	1	6	1,00	1,00
Item 4	1	1	1	1	1	1	6	1,00	1,00
Item 5	1	1	1	1	1	1	6	1,00	1,00
Item 6	1	1	1	1	1	1	6	1,00	1,00
Item 7	1	1	1	1	1	1	6	1,00	1,00
Item 8	1	1	1	1	1	1	6	1,00	1,00
Item 9	1	1	1	1	1	1	6	1,00	1,00
Item 10	1	1	1	1	1	1	6	1,00	1,00
%Agreement	100%								

Source: Excel Processing Results (2026)

The results of the content validity test using the Content Validity Ratio (CVR) showed that all items obtained a CVR value of 1.00. The value indicates that all validators are in full agreement that each item belongs to an essential

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or highly relevant category. With a total of 6 validators, the CVR value of 1.00 has exceeded the required minimum limit, so that all items are declared valid. In addition, the Content Validity Index (CVI) on each item also obtained a value of 1.00. An average CVI of 1.00 indicates that the level of suitability of the overall content of the instrument is in the very high or very valid category. Thus, the instrument or medium used has excellent content validity and is suitable for application in research.

In the reliability test using Percentage Agreement (PA), the average value of validator assessment was 1 for each assessor, with an agreement value (R) of 1.00 or equivalent to a 100% agreement percentage level. These results show that consistency and agreement between validators are at a very high level. Therefore, the instrument is stated to have excellent reliability and can be trusted as a data collection tool in research.

CVR CVI and Percentage Agreement for Subject Matter Experts

Table 2 Expert Assessment

Assessment Aspects	V1	V2	V3	V4	V5	V6	Ne	CVR	CVI
Item 1	1	1	1	1	1	1	6	1,00	1,00
Item 2	1	1	1	1	1	1	6	1,00	1,00
Item 3	1	1	1	1	1	1	6	1,00	1,00
Item 4	1	1	1	1	1	1	6	1,00	1,00
Item 5	1	1	1	1	1	1	6	1,00	1,00
Item 6	1	1	1	1	1	1	6	1,00	1,00
Item 7	1	1	1	1	1	1	6	1,00	1,00
Item 8	1	1	1	1	1	1	6	1,00	1,00
Item 9	1	1	1	1	1	1	6	1,00	1,00
Item 10	1	1	1	1	1	1	6	1,00	1,00
Item 11	1	1	1	1	1	1	6	1,00	1,00
Item 12	1	1	1	1	1	1	6	1,00	1,00
Item 13	1	1	1	1	1	1	6	1,00	1,00
Item 14	1	1	1	1	1	1	6	1,00	1,00
Item 15	1	1	1	1	1	1	6	1,00	1,00
Item 16	1	1	1	1	1	1	6	1,00	1,00
%Agreement	100%								

Source: Excel Processing Results (2026)

The results of the content validity test using the Content Validity Ratio (CVR) showed that all items obtained a CVR value of 1.00. The value indicates that all validators agree on each item as an essential or highly relevant category. With a total of 6 validators, the CVR value of 1.00 has exceeded the required minimum limit, so that all

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items are declared valid. In addition, the Content Validity Index (CVI) on each item also obtained a value of 1.00. An average CVI of 1.00 indicates that the level of suitability of the overall content of the instrument is in the very high or very valid category. Thus, the material used in the research has excellent content validity and is suitable for application.

In the reliability test using Percentage Agreement (PA), the average value of validator assessment was obtained of 1.00 for each assessor, with an agreement value (R) of 1.00 or equivalent to a 100% agreement percentage. These findings demonstrate that there is a very high degree of agreement and consistency among validators. Therefore, the material is stated to have excellent reliability and can be trusted as an instrument in research.

Validity of Aiken's V and Reliability of the ICC Test Test Question Expert

Table 3 Test Question Assessment

Assessment Aspects	V1	V2	V3	V4	V5	V6	$\sum s$	n(c-1)	v
Item 1	3	4	3	3	4	3	14	18	0,78
Item 2	2	3	3	2	3	2	9	18	0,50
Item 3	4	4	3	4	4	3	16	18	0,89
Item 4	3	2	3	3	2	3	10	18	0,56
Item 5	2	2	3	2	2	3	8	18	0,44
Item 6	4	3	4	4	3	4	16	18	0,89

Source: Excel Processing Results (2026)

Based on the results of the validity test using Aiken's V, a validity value was obtained for each item that showed a variation in the level of eligibility. Item 1 obtained a value of 0.78 which is included in the category of quite valid. Item 2 has a value of 0.50 and is in the category of moderate validity. Item 3 obtained a value of 0.89 which belongs to the very valid category. Furthermore, Item 4 has a value of 0.56 which is classified as moderately valid, Item 5 obtains a value of 0.44 which is also included in the category of moderate validity, and Item 6 obtains a value of 0.89 which is again in the very valid category. Overall, the results show that all items are in the medium to very valid category range. Thus, the instrument is declared quite feasible for use in the research, although there are still some items that are in the category of moderate valid and can be considered for further improvement so that the quality of the instrument is more optimal.

Table 4 ICC

		95% Confidence Interval		F Test with True Value 0			
	Intraclass Correlation[b]	Lower Bound	Upper Bound	Value	df1	df2	Sig
Average Measures	0,871	0,578	0,980	6,730	5	25	0,000

Source: IBM SPSS Statistic 25 Processing Results (2026)

Furthermore, the results of the reliability test using the Intraclass Correlation Coefficient (ICC) showed that the Average Measures value was 0.871 which was included in the high reliability category. This indicates that if the assessment is based on an average of six validators, then the results are consistent and trustworthy. In addition, a significance value of 0.000 (< 0.05) indicates that the ICC results are statistically significant, so the level of agreement between validators does not occur by chance. Thus, this research instrument has a good level of reliability and is declared feasible to use, especially if using the average assessment from the validators as the basis for analysis.

Data Analysis

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Descriptive Analysis

Tabel 5 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Pretest Control	25	42	62	51.44	5.339	28.507
Posttest Control	25	64	84	73.12	5.167	26.693
Pretest Experiments	25	44	64	53.44	5.339	28.507
Posttest Experiment	25	84	100	92.88	4.729	22.360
Valid N (listwise)	25					

Source: IBM SPSS Statistic 25 Processing Results (2026)

Based on the results of the descriptive analysis, it was obtained that the average pretest score in the control class was 51.44 with a standard deviation of 5.339, while the average posttest score increased to 73.12 with a standard deviation of 5.167. Meanwhile, in the experimental class, the average pretest score was 53.44 with a standard deviation of 5.339 and increased to 92.88 in the posttest with a standard deviation of 4.729. The findings demonstrated that after receiving classroom instruction, both classes' learning outcomes increased. However, the improvement that occurred in the experimental class was higher than in the control class, so it can be indicated that the treatment given in the experimental class had a more effective effect on improving student learning outcomes.

Normality Test

Tabel 6 Tests of Normality

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Classes	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Results	**Control Class Pretest**	.100	25	.200*	.976	25	.791
	Control Class Posttest	.106	25	.200*	.978	25	.838
	Experimental Class Pretest	.100	25	.200*	.976	25	.791
	Posttest Experiment Class	.105	25	.200*	.955	25	.325

Source: IBM SPSS Statistic 25 Processing Results (2026)

The results of the normality test using Kolmogorov-Smirnov and Shapiro-Wilk showed that all data had a significance value greater than 0.05. In the Shapiro-Wilk test, the significance value of the control class pretest was 0.791, the control class posttest was 0.838, the experimental class pretest was 0.791, and the experimental class posttest was 0.325. Based on these results, all data were declared to be normally distributed because the significance value obtained was greater than 0.05. Thus, the research data has met the assumption of normality so that it is feasible to analyze using parametric statistical tests at the next stage.

Homogeneity Test

Tabel 7 Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Results	**Based on Mean**	.162	3	96	.922

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Source: IBM SPSS Statistic 25 Processing Results (2026)

The homogeneity test using the Levene Test showed a significance value of 0.922 based on the mean. The value is greater than 0.05, so it can be concluded that the variance of data between the control class and the experimental class is homogeneous. The study data is now eligible for additional examination using a parametric statistical test, specifically an independent sample t-test, as the assumptions of normality and homogeneity have been fulfilled.

Independent Sample T-Test

Tabel 8 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Results	**Equal variances assumed**	.109	.743	-14.107	48	.000
	Equal variances not assumed			-14.107	47.628	.000

Source: IBM SPSS Statistic 25 Processing Results (2026)

The results of the hypothesis test using an independent sample t-test showed a significance value (2-tailed) of 0.000 (< 0.05) with a calculated t-value of -14.107. This shows that there is a significant difference between the learning outcomes of the control class and the experimental class. In addition, the average posttest score of the control class was 73.12, while the experimental class was 92.88, with an average difference of 19.760. These findings suggest that there is significant difference between the two groups. Therefore, as compared to traditional learning, the utilization of flipbook-based interactive learning materials significantly improves student learning results.

N-Gain Analysis

Tabel 9. N-Gain

N_Gain%	**Control Class**	**Mean**	45,14	**Experimental Classes**	**Mean**	85,64
		Median	44,00		**Median**	83,33
		Variance	25,107		**Variance**	74,643
		Std. Deviation	5,011		**Std. Deviation**	8,640
		Minimum	38		**Minimum**	71
		Maximum	58		**Maximum**	100
		Range	20		**Range**	29

Source: IBM SPSS Statistic 25 Processing Results (2026)

The control class obtained an average N-Gain of 45.14% which was included in the medium category, while the experimental class obtained an average of 85.64% which was included in the high category. These findings demonstrate that the experimental class's learning results improved greater than those of the control group. Thus, it can be concluded that flipbook-based interactive learning media is more effective in improving students' understanding of the functional material of milling machine parts compared to conventional learning.

DISCUSSION

Sosioedukasi
JURNAL ILMIAH ILMU PENDIDIKAN DAN SOSIAL
ISSN: 2086-6135 E-ISSN: 2541-612x
Volume 15 No. 2. June 2026 https://ejournal.unibabwi.ac.id/index.php/sosioedukasi/index

Based on the validation conducted by media and material experts, the flipbook-based e-module developed in this study can be categorized as highly feasible for implementation in vocational learning. The strong validity and reliability results indicate that the content, presentation, and instructional design of the e-module are aligned with learning objectives and student characteristics. From an instructional design perspective, the quality of learning media is an essential prerequisite for achieving effective learning outcomes because valid and reliable learning resources facilitate meaningful knowledge construction and reduce misconceptions during the learning process.

The findings reveal that students who learned through the flipbook-based e-module achieved better learning outcomes than those who received conventional instruction. This result is consistent with previous studies reporting that flipbook-based e-modules contribute positively to students academic achievement by providing structured content, multimedia integration, and flexible access to learning materials. Oktariamlati Rahmagandi et al., (2024) found that flipbook-based e-modules significantly improved vocational students' achievement in manufacturing design learning, while Syifa et al., (2024) reported similar improvements in students' mastery of welding symbols through technology-enhanced learning materials. These studies support the present findings by suggesting that digital modules can facilitate deeper conceptual understanding compared with traditional printed resources.

The effectiveness of the flipbook-based e-module can be explained through the principles of multimedia learning theory proposed by Mayer, which states that students learn more effectively when information is presented through a combination of text and visual representations. In the context of milling machine components, students are required to understand the shape, location, function, and relationship among machine parts. These concepts are often difficult to comprehend through verbal explanations alone. The interactive visualizations provided by the flipbook e-module help students construct mental models of machine structures, thereby reducing cognitive load and enhancing conceptual understanding. Similar findings were reported by Zakiyah & Dwiningsih, (2022), who demonstrated that interactive e-modules improved students' visual-spatial abilities and facilitated the learning of abstract concepts.

Another important finding is that students appeared more engaged during learning activities when using the flipbook-based e-module. This condition may be attributed to the interactive nature of digital learning media, which encourages active exploration and self-directed learning. Unlike conventional classroom instruction that is often teacher-centered, flipbook media enables students to revisit materials independently, control their learning pace, and access content through digital devices. These characteristics are in line with constructivist learning theory, which emphasizes the active role of learners in constructing knowledge. Similar findings were reported by Ghifari & Linggowati, (2024), who found that flipbook-based digital learning media increased students' motivation and participation during the learning process because the content was presented in a more attractive and accessible format. Likewise, Fatma Febriyanti et al., (2025) concluded that interactive e-modules enhanced students' learning engagement and supported independent learning habits, allowing learners to take greater responsibility for their own learning progress. These findings strengthen the argument that the effectiveness of flipbook-based e-modules is not only associated with cognitive improvement but also with increased motivation and active involvement in learning activities.

The significant difference observed between the experimental and control groups further indicates that the improvement in learning outcomes was not merely caused by normal classroom learning processes but was associated with the instructional intervention itself. Compared with conventional textbooks, flipbook-based e-modules offer richer learning experiences through the integration of visual elements, interactive navigation, and digital accessibility. This finding is consistent with Suprayogi et al., (2024), who reported that Flipbook Maker-based e-modules significantly improved students' understanding of automotive starter systems, and Bayhaki & Untari, (2023), who found that flipbook learning media positively affected vocational students' learning outcomes. However, unlike previous studies that focused primarily on general learning achievement, the present study specifically demonstrates the effectiveness of flipbook-based e-modules in supporting the understanding of technical and visual concepts related to milling machine components, which require strong spatial and functional comprehension.

Overall, the findings suggest that flipbook-based e-modules are not only effective as digital learning resources but also function as instructional tools that facilitate visualization, increase learner engagement, and promote

Sosioedukasi
JURNAL ILMIAH ILMU PENDIDIKAN DAN SOSIAL
ISSN: 2086-6135 E-ISSN: 2541-612x
Volume 15 No. 2. June 2026 https://ejournal.unibabwi.ac.id/index.php/sosioedukasi/index

independent learning. Their effectiveness appears particularly relevant in vocational education, where students must understand technical systems and component functions before engaging in practical workshop activities. Therefore, integrating flipbook-based e-modules into vocational learning may help bridge the gap between theoretical understanding and practical competence, contributing to more meaningful and technology-enhanced learning experiences in machining engineering education.

CONCLUSION

The findings of this study indicate that the implementation of a flipbook-based e-module contributes positively to improving students learning outcomes in the topic of understanding the functions of milling machine parts among Grade XI students in the Machining Engineering Expertise Program at SMK Negeri 1 Karangawen. The learning approach supported by the flipbook-based e-module resulted in better achievement and greater learning improvement when compared with conventional learning methods. Furthermore, the developed learning media and the instruments used in this research demonstrated satisfactory levels of validity and reliability, confirming their suitability for instructional and research purposes. These results highlight the potential of flipbook-based e-modules as an innovative digital learning medium that can facilitate students comprehension of technical concepts requiring visual representation. From a practical perspective, the use of such e-modules may assist vocational school teachers in delivering learning materials more effectively while encouraging greater student engagement and independent learning. Nevertheless, the scope of this research was limited to a single vocational school and a specific group of students; therefore, future studies involving larger samples and different vocational education contexts are needed to provide broader evidence regarding the effectiveness of flipbook-based e-modules.

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ISSN: 2086-6135 E-ISSN: 2541-612x
Volume 15 No. 2. June 2026 https://ejournal.unibabwi.ac.id/index.php/sosioedukasi/index

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