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Development of a Flipbook-Based E-Module to Enhance Learning Outcomes in Manufacturing Design for Vocational High School Students

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Abstract

Limited understanding of 2D and 3D sketching using Autodesk Inventor Drawing, constrained by conventional teaching methods and the lack of adequate learning modules, remains a significant challenge in the manufacturing design course for Mechanical Engineering students at SMK Negeri 5 Semarang. This issue directly impacts student learning outcomes. This study aims to develop a flipbook-based e-module to improve learning achievements, with its effectiveness analyzed through t-tests and N-gain tests. The research employed the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). An experimental method was applied using a pretest-posttest control group design, involving 64 students divided into an experimental class and a control class. The results indicated that the developed e-module, including its content, media, and assessment instruments, was deemed feasible for use. Statistical analysis revealed a significant improvement in the experimental class compared to the control class, as evidenced by a t-value greater than the critical t-table value (7.664 > 1.998). Furthermore, the N-gain test showed a moderate increase in the experimental class (0.56) compared to the control class (0.32), demonstrating an enhancement in student learning outcomes. This study highlights the positive impact of integrating technology into education and emphasizes the importance of innovative teaching methods in advancing student competencies in manufacturing design.

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INTRODUCTION

Vocational education must maintain a high quality and continue to evolve in order to meet and create technological advancements in line with industrial demands. According to Vachruddin et al. (2023), vocational high school (SMK) graduates are prepared to enter professional fields through industry-based competency assessments and are expected to remain competitive in the advancement of science and technology. The principles of vocational education, as outlined by Dr. Charles Allen Prosser in his Sixteen Theorems, emphasize several key concepts of vocational training (Syifa et al., 2024). Mastery of 2D and 3D sketch design using Autodesk Inventor falls under the second category, providing students with clear conceptual knowledge applicable in the workplace. The effectiveness of e-modules, as highlighted in the tenth theorem, suggests that delivering learning materials through a flipbook-based e-module promotes more effective understanding compared to conventional methods.

The competency achievement in manufacturing design drawing among Mechanical Engineering students at SMK Negeri 5 Semarang remains suboptimal. This is evident from the average skill score of the eleventh-grade Mechanical Engineering students, which reached only 68.68%, falling below the criteria for learning objective achievement. Classroom observations revealed a lack of student feedback during teachers explanations, the absence of teaching modules, and the continued reliance on conventional teaching methods, all of which present significant challenges for students in comprehending the learning materials. These findings align with the research of Patmasari et al. (2023), who stated that teachers roles as facilitators in the learning process are expected to create digital-based learning designs to foster active participation, creative thinking, and a dynamic classroom atmosphere. Additionally, Nurhayati et al. (2018) emphasized that the roles of teachers and the learning process are critically important in education.

Research conducted by Subroto et al. (2023) indicated that developments in information and communication technology have driven innovations in digital teaching modules, presenting both challenges and opportunities for teachers to innovate and create engaging learning media. Electronic teaching modules are books in software form that offer greater practicality compared to printed modules. E-modules, being interactive, provide navigation features and integrate images, audio, video, animations, and formative assessments. Consistent with the findings of Surtikanti et al. (2024), digital modules offer educators the opportunity to innovate by transforming printed materials into electronic formats, facilitating independent online study and aligning with modern educational trends.

The development of e-modules often involves additional software tools such as flipbooks. A flipbook is an animated book-like program that presents content in various output formats, enriched with features such as hyperlinks, videos, animations, audio, worksheets, and systematically organized assessments for interactive learning. Furthermore, flipbooks are digital learning modules resembling magazines, typically sized at 21 by 29 centimeters (A4 format). Flipbook technology, as a professional software, enables the creation of electronic books featuring interactive elements such as animations, audio, and video. Flipbook-based e-modules actively engage students in the learning process, as highlighted by Awwaliyah et al. (2021). Research by P. Oronce and O. Manalo (2021) also emphasized that flipbook-based e-modules remain viable learning tools that adapt to rapid technological developments and positively influence students interest and learning outcomes.

The objectives of this study are as follows: (1) to develop an Inventor Drawing e-module for the Manufacturing Design Drawing course; (2) to analyze the feasibility of the Inventor Drawing e-module in improving learning outcomes in the Manufacturing Design Drawing course; (3) to analyze the effectiveness of the Inventor Drawing e-module on students learning achievements in the Manufacturing Design Drawing course; and (4) to analyze the improvement of learning outcomes following the implementation of the

Inventor Drawing e-module in the Manufacturing Design Drawing course.

METHODOLOGY

This study employed a product development research approach, specifically a research and development (R&D) study, utilizing the ADDIE model. The ADDIE model was structured systematically with a sequence of activities designed to address issues related to learning resources (Rasmi et al., 2023). The research design adopted a two-group pretest-posttest control group design.

Table 1. Pretest-Posttest Control Group Design.

Group	Pre test	Treatment	Post test
(R) E	O1	X	O2
(R) K	O3	-	O4

Information: R = Random, E = Experimental Group, K = Control Group, X = Treatment, - = Without Treatment, O1 = Pretest of Experimental Group, O2 = Posttest of Experimental Group, O3 = Pretest of Control Group, O4 = Posttest of Control Group.

The subjects of this study were eleventh-grade students majoring in Mechanical Engineering (TM) at SMK Negeri 5 Semarang, comprising two classes, TM1 and TM2, with a total of 64 students. Class TM2, consisting of 32 students, was designated as the experimental group, while class TM1, also comprising 32 students, served as the control group. The sampling technique employed was simple random sampling, which involved selecting samples randomly from the population without considering differences and ensuring that every member of the population had an equal chance of being selected.

Data collection was conducted through assessment rubrics evaluated by subject matter experts, media experts, and test instrument experts to measure the usability of the developed product. Meanwhile, the effectiveness of the product was assessed by comparing the pretest and posttest results using t-tests and N-gain tests. According to Yulyantari (2018), assessment rubrics play a crucial role in ensuring the quality of a product or research instrument, thus the number of questions developed must correspond to the indicators of the research variables.

RESULT

Based on data analysis, this study involved the development and evaluation of a flipbook-based e-module aimed at improving learning outcomes in 2D and 3D sketch design within the Manufacturing Drawing course. According to the rubric assessment for content expert validation, the content validity index (CVI) was calculated at 0.991, and the reliability test using the percentage of agreement (PA) reached 99.1%, categorized as "highly feasible." In addition, media expert validation using the content validity ratio (CVR) from eight experts produced a result of 0.6319 > 0.75, with a PA reliability score of 96.66%, also classified as "highly feasible." Thus, the evaluations by both content and media experts indicate that the flipbook-based e-module is highly feasible for use in terms of both content and media design.

Table 2. Results of Feasibility Analysis by Media Experts and Content Experts

Content Expert	Score	Media Expert	Score
Assessor 1	15	Assessor 1	13
Assessor 2	15	Assessor 2	13
Assessor 3	15	Assessor 3	15
Assessor 4	15	Assessor 4	15
Assessor 5	15	Assessor 5	15
Assessor 6	15	Assessor 6	15
Assessor 7	14	Assessor 7	15
Assessor 8	15	Assessor 8	15
Total Score	119	Total Score	118
Maximum Score	120	Maximum Score	120
Percentage	99.10%	Percentage	96.66%
Category	Highly Feasible	Category	Highly Feasible

Further feasibility analysis was conducted by five test instrument experts, who assessed a total of 25 test items. Using Aiken's validity test,

it was determined that all items were valid except for items number 1 and 25, which had a V value less than 0.75. The reliability test for the instrument was conducted using IBM SPSS Statistics 26 and the ICC (Intraclass Correlation Coefficient) method, resulting in a value of 0.910, which is greater than 0.70, indicating that the instrument is reliable. Overall, it can be concluded that the flipbook-based e-module is feasible and effective for use.

Additionally, pretest and posttest evaluations were conducted involving eleventh-grade Mechanical Engineering students at SMK Negeri 5 Semarang, consisting of 32 students in the experimental class and 32 students in the control class. The pretest results for both groups were analyzed using a two-tailed t-test, aiming to compare two independent sample groups and to determine whether the differences between them were statistically significant. The results showed that the t-calculated value was greater than the t-table value (4.080 > 1.998) and the significance level (Sig. 2-tailed) was 0.000 < 0.05, indicating that the two groups had significantly different abilities.

The posttest results were analyzed using descriptive analysis, normality tests, homogeneity tests, right-tailed t-tests, and N-gain tests. The descriptive analysis results for the experimental class showed an increase in pretest and posttest scores from 68 to 96, while the control class showed an increase from 60 to 80. In the normality test, using the Shapiro-Wilk statistic, the control class obtained a value of 0.935 with a significance level of 0.054 > 0.05, and the experimental class obtained a value of 0.960 with a significance level of 0.272 > 0.05, indicating that the data were normally distributed. The homogeneity test resulted in a significance value of 0.054 > 0.05, confirming that the data were homogeneous. The right-tailed t-test (independent sample t-test) showed that the t-calculated value was greater than the t-table value (7.664 > 1.998), and the significance level (Sig. 2-tailed) was 0.000 < 0.05. These results reveal a significant difference in posttest performance between the experimental and control groups.

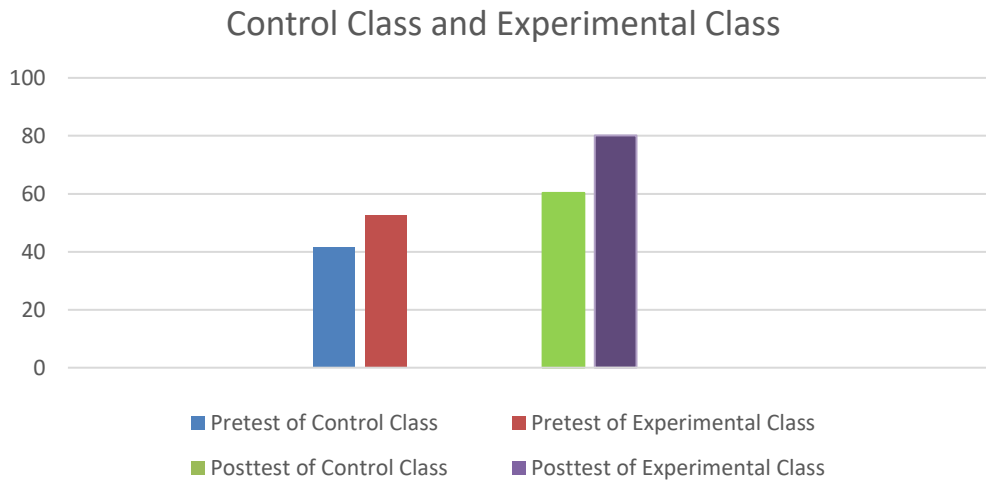

Figure 1. Diagram of Learning Achievement Results for Control and Experimental Classes

The results illustrated in the diagram indicate a difference in the improvement between the control and experimental classes. In the control class, the pretest score was 41.75, while the experimental class achieved a pretest score of 52.75, suggesting a slight initial difference between the two groups. The posttest result for the control class reached 60.38, whereas the experimental class achieved 80.13. The improvement in learning outcomes for the control class was 18.63 points or 32.43%, indicating progress in mastering 2D and 3D sketching using conventional methods. In contrast, the experimental class showed an improvement of 27.38 points or 56.65%, demonstrating a more significant enhancement in understanding 2D and 3D sketching through the use of inventor drawing with the flipbook-based e-module.

Based on the N-gain test results, the average posttest score for the experimental class

was 0.5665 or 56.65%, categorized as "moderately effective," compared to the control class, which reached 32.43%. This finding supports the conclusion that the learning intervention using the flipbook-based e-module contributed to improved student understanding of the material, thereby having a positive impact on students learning outcomes.

DISCUSSION

The flipbook-based e-module developed in this study was intended to enhance student learning outcomes in mastering 2D and 3D sketching using Autodesk Inventor Drawing for eleventh-grade Mechanical Engineering students. The development process followed the ADDIE model, which consists of five stages: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Agustina et al., 2023). The analysis phase involved identifying the needs and characteristics of the e-module, as well as conducting curriculum and technology analyses (Priyantama et al., 2024). Observations revealed several issues within the Manufacturing Drawing course, including low student interest in learning materials, limited use of technology by teachers, and the need for independent learning media. The design phase involved creating the e-module framework and selecting references, focusing on an attractive layout to increase student engagement, particularly through the use of technologies such as smartphones. An appealing design was expected to support students understanding of 2D and 3D sketching concepts.

Electronic modules offer several advantages, primarily their effectiveness, practicality, and portability. With technological advancements, particularly smartphones, students can access learning materials without limitations of time and space. This aligns with the characteristics of twenty-first-century learning, which emphasizes technological development. The flipbook-based e-module provides an interactive and engaging learning experience, thereby enhancing learning outcomes and improving student competencies (Mulia et al., 2024).

Hasibuan et al. (2023) revealed that the development of flipbook-based e-modules is highly practical and effective, especially in attracting students attention. Similarly, Noer Arifin and Aini Susanti (2018) stated that the use of flipbook-based e-modules can improve student learning outcomes, particularly in Autodesk Inventor materials. Therefore, the development of flipbook-based e-modules is a highly appropriate solution to address challenges in teaching 2D and 3D sketching using Autodesk Inventor Drawing in the eleventh-grade Mechanical Engineering class. Feedback and evaluation from its implementation are expected to serve as a foundation for further improving the quality of instruction in the future.

This flipbook-based electronic module underwent a validation process to determine its feasibility before being tested with students. The validation involved several validators, including content experts, media experts, and test instrument experts. The results from eight content experts showed an average score of 99.10%, classified as highly feasible, while the eight media experts gave an average score of 98.30%, also classified as highly feasible. Additionally, the test instrument reliability, with a score of 0.910, indicated that it was reliable and suitable for use.

Rosita et al. (2021) explained that validity testing is conducted to determine whether the instruments used to measure a product meet feasibility standards. Research by Bisri et al. (2023) found that e-modules developed using Flipbook achieved an average content validity of 97.33% and media validity of 91.16%, both classified as highly feasible. Yuliani and Setiawan (2024) also noted that the feasibility of electronic modules received a very high rating, with a percentage of 92.5% classified as highly feasible.

Overall, the development of the flipbook-based e-module has proven effective in meeting students needs and enhancing learning outcomes in mastering 2D and 3D sketching within the Manufacturing Drawing course. This conclusion is supported by expert validation results and the pretest and posttest findings. The right-tailed t-test analysis of the posttest results, with a t-value of 7.664 greater than the t-table value of 1.998 and a significance value of 0.000 less than 5%, confirms a significant improvement in the material taught

using the flipbook-based e-module. The average mastery learning score of 0.5665 falls into the moderate category.

CONCLUSION

Based on the results and discussion of this study, the following conclusions can be drawn: (1) The development of the Inventor Drawing E-Module for the Manufacturing Drawing course using the ADDIE model has been successfully completed and tested; (2) The developed Inventor Drawing E-Module is highly feasible for use in the learning process; (3) The Inventor Drawing E-Module significantly enhances the effectiveness and learning achievements of students in the Manufacturing Drawing course; (4) There is a significant improvement in student learning outcomes, with an N-gain score of 0.5665 or 56.65%, which is higher compared to the conventional teaching methods applied by the teacher.

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