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THE EFFECT OF MOBILE LEARNING-BASED ELECTRONIC MODULES ON LEARNING OUTCOMES IN COMPUTER SCIENCE SUBJECTS FOR VOCATIONAL HIGH SCHOOL STUDENTS

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Abstrak

Penelitian ini bertujuan guna mengevaluasi pengaruh modul elektronik berbasis *mobile learning* (flipbook) dalam meningkatkan hasil belajar siswa kelas X pada mata pelajaran Informatika di SMK Negeri 7 Bone. Penelitian ini mengaplikasikan desain kuantitatif pra-eksperimen dengan pendekatan *one-group pretest dan posttest*, dimana melibatkan satu kelas sebagai kelompok perlakuan dalam penelitian. Sebanyak 14 siswa dipilih menggunakan teknik *non-probability sampling*. Hasil belajar kognitif diukur melalui tes pilihan ganda yang diberikan sebelum dan setelah intervensi, dengan semua item telah divalidasi sebelumnya untuk reliabilitas dan akurasi. Analisis data yang dilakukan menggunakan uji t-tests dengan SPSS 26 menunjukkan adanya peningkatan signifikan secara statistik pada prestasi siswa, dengan rata-rata skor meningkat dari angka 44 pada pretest menjadi 85 pada posttest. Temuan ini menunjukkan bahwa penerapan flipbook berbasis *mobile learning* secara substansial meningkatkan pemahaman dan penguasaan konsep Informatika oleh siswa, mendukung efektivitasnya sebagai alat pembelajaran inovatif yang mendorong pembelajaran aktif, keterlibatan, dan peningkatan hasil belajar di pendidikan menengah kejuruan.

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Kata kunci: flipbook; mobile learning; hasil belajar.

Abstract

This study aims to evaluate the effect of a mobile learning–based electronic module (flipbook) on improving the learning outcomes of tenth-grade students in the Informatics subject at SMK Negeri 7 Bone. The research employed a quantitative pre-experimental design using a one-group pretest–posttest approach, involving a single class as the treatment group. A total of 14 students were selected through a non-probability sampling technique. Cognitive learning outcomes were measured using multiple-choice tests administered before and after the intervention, with all test items previously validated for reliability and accuracy. Data analysis conducted using t-tests with SPSS version 26 revealed a statistically significant improvement in students'

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performance, with the mean score increasing from 44 on the pretest to 85 on the posttest. These findings indicate that the implementation of the mobile learning–based flipbook substantially enhances students' understanding and mastery of Informatics concepts, supporting its effectiveness as an innovative instructional tool that promotes active learning, engagement, and improved learning outcomes in vocational secondary education.

***Keywords**: flipbooks; mobile learning; learning outcomes.*

I. Introduction

The rapid development of information and communication technology has brought significant changes to the field of education. The integration of technology in teaching and learning activities is now a key requirement for improving the quality of the learning process. Information and communication technology has the potential to improve the quality of education, provide better access to students, and create a more dynamic learning environment. The use of digital technology enables the learning process to be more interactive, flexible, and student-centered. One form of technology-based educational innovation is the development of electronic modules integrated with mobile learning, where students can study material through devices such as smartphones and tablets (UNESCO 2020).

Mobile learning (m-learning) is an electronic module that allows students to access learning materials anywhere and anytime through mobile devices. However, the use of digital media at SMK Negeri 7 Bone is not yet optimal, especially in Informatics classes, which are still dominated by conventional methods. This condition has implications for low motivation and learning outcomes among students. Therefore, innovative media such as electronic modules in the form of digital flipbooks are needed to improve learning outcomes, especially in Informatics lessons that require logical and technological thinking skills (Prabowo 2021; Hidayati 2021).

Along with this, the use of digital technology in the learning process allows learning to take place flexibly and be student-centered. One form of digital learning implementation that is growing rapidly is electronic modules, which are interactive digital learning media that integrate text, images, videos, and animations. Its advantages lie in its flexibility, interactivity, and ability to increase learning motivation (Darsono 2021; Hamid 2023). E-modules can be accessed online or offline and support independent learning (Widyastuti 2020).

The development of e-modules as a means of digital learning is inseparable from technological advances that have led to the emergence of more interactive and accessible forms of learning. While e-modules enable students to learn independently through computers or online platforms, this innovation has evolved further into mobile learning, which is learning using mobile devices that allow unlimited access to learning

regardless of time and place (Traxler 2021). M-learning is flexible and supports collaboration between students and teachers through digital applications (Ally 2022). This approach improves digital literacy and learning independence (Kukulska-Hulme 2021), but it still depends on the quality of content and the availability of technology (Cavus, N., & Ibrahim 2021; Yusoff 2022). In the context of informatics, m-learning is effective in encouraging student motivation, collaboration, and learning outcomes (Purwanto, A., & Nuryadin 2021).

In the context of this study, flipbook-based modules were chosen because they are considered relevant to the demands of 21st-century learning, which emphasizes independence, flexibility, and interactivity. Based on observations at SMK Negeri 7 Bone, informatics learning still faces a number of obstacles, including low student motivation, limited facilities, and conventional teaching methods.

Flipbooks are considered effective because they combine the appearance of a printed book with additional multimedia elements such as animations, videos, interactive images, and evaluative exercises that can be accessed via mobile devices. These advantages provide opportunities for students to hone their skills independently and contextually according to their individual needs. With an attractive display and a more dynamic learning experience, the use of mobile learning-based flipbooks is expected to increase student motivation, participation, and learning outcomes in Informatics subjects at vocational schools.

Through easy access to materials, time flexibility, and intense digital interaction between teachers and students, mobile learning is expected to support the achievement of optimal learning goals. Therefore, the effectiveness of mobile learning implementation can be seen through improved learning outcomes, which reflect student achievement in cognitive, affective, and psychomotor aspects (Susanto 2021). Factors that influence learning outcomes include motivation, interest, physical condition, environment, teaching methods, and facilities (Rahmawati 2022). Learning outcomes are evaluated through tests, observations, and portfolios to measure learning success (Arikunto 2020; Daryanto 2021; Sukardi 2021).

In the context of Informatics, the application of e-modules and mobile learning is highly relevant because Informatics serves to shape students' digital literacy and computational thinking skills in preparation for the era of the Fourth Industrial Revolution. In addition to developing logical and algorithmic thinking skills, Informatics also instills digital ethics and cyber security values (Hardiana 2021; Nugraha, A., & Widiyanto 2023). However, the main challenges in Informatics learning include limited facilities, teacher competence, and low student motivation (Setiawan 2021; Sari, D., & Rahman 2022). Project-based approaches and the use of dynamic media such as e-modules have been shown to increase student interest and learning outcomes (Pratama 2020; Rahayu 2023). Thus, the integration of e-modules and mobile learning

in Informatics not only improves learning outcomes but also prepares students to meet the demands of 21st-century competencies.

Research shows that the use of e-modules improves student retention and learning outcomes because they present material in an interesting and easy-to-understand way (Suparman 2019). However, the main challenges to their use are limitations in infrastructure and teachers' digital capabilities (Prasetyo, E., & Nugroho 2021).

Previous research, such as that by Utami, N., Gimin, G., & Riadi (2022), proves that mobile learning is more effective in optimizing the economic learning outcomes of high school students. Saidah (2022) developed a mobile learning-based e-module that improves students' research skills, while Minan, D. A., & Ekohariadi (2022) found that Glide Apps-based e-modules are effective in vocational learning. However, most studies focus on media development, and not many have empirically tested the effect of its use on learning outcomes in vocational schools.

The novelty of this study lies in the implementation of an electronic module integrated with mobile learning in Informatics education at the vocational high school level, with an emphasis on empirical testing of its effectiveness through a one-group pretest–posttest design. This study is of high urgency given that Informatics subjects in vocational high schools play an important role in preparing students to have digital competencies relevant to the needs of today's world of work.

This research aims to analyze the effect of using mobile learning-based electronic modules on improving student learning outcomes in vocational high schools. By integrating technology into the learning process, this study seeks to provide empirical evidence on how digital learning tools can support student achievement in the context of vocational education. The findings of this research are expected to contribute significantly to the innovation of technology-enhanced learning practices and serve as a practical reference for educators in designing innovative, flexible, and adaptive digital-based learning strategies. Ultimately, this study highlights the potential of mobile learning modules to encourage active engagement, improve understanding, and enhance overall academic achievement.

II. Research Method

This study applies a quantitative approach with a pre-experimental design. A quantitative approach was chosen because this study focuses on testing hypotheses related to the effect of using mobile learning-based electronic modules in the form of flipbooks on improving student learning outcomes in Informatics. This approach emphasizes objective measurement of research variables through data collection and analysis using statistical methods.

This study applies a pre-experimental design because it involves only one research group without a control group, so randomization cannot be applied. Although relatively simple, this design is still effective for evaluating the impact of an intervention on

student learning outcomes by comparing their performance before and after treatment. In the context of this study, the intervention consisted of the application of a mobile learning-based electronic module (flipbook) in the learning process. This approach allows for systematic observation of changes in cognitive performance and provides valuable insights into the potential of technology-based learning tools in the context of vocational education.

Data collection was conducted at State Vocational High School 7 Bone, located in Biru Village, Tanete Riattang Subdistrict, Bone Regency, South Sulawesi Province. This school was chosen as the location for the study because it already had infrastructure that supported technology-based learning, although the use of digital media, especially in the Informatics curriculum, was still not optimal. This condition provides a relevant context for researching the effectiveness of mobile learning interventions in improving learning outcomes.

The research was conducted in the even semester of the 2024/2025 academic year, specifically from April to May 2025. During this period, the researchers carried out a series of research activities, including instrument preparation, implementation of learning with flipbook media, administration of pre-tests and post-tests, and data analysis using SPSS version 26 software.

The population in this study included all 52 students in grade X at State Vocational High School 7 Bone for the 2024/2025 academic year, divided into five skill programs, namely:

1. Grade X Hospitality students (10 students)
2. Grade X Visual Communication Design students (14 students)
3. Grade X Broadcasting and Film students (3 students)
4. Grade X Marketing and Retail Business students (20 students)
5. Grade X Fashion Design and Production students (5 students)

In this study, a non-probability sampling method was used, in which not all populations had the same chance of being selected. Specifically, purposive sampling was applied, which is the selection of participants based on certain criteria deemed relevant and appropriate to the research objectives. This approach ensures that the sample used is relevant to the research focus and increases the validity of the findings.

The criteria for sample selection include:

1. Students are in grade X.
2. Students are from the Visual Communication Design (DKV) program.
3. Students are taking Informatics courses in the current semester.
4. Students have not previously received Computer Systems material.
5. Students have mobile devices (smartphones) and adequate internet access.

6. The class and teacher are willing to collaborate in the research activities.

Using several criteria for sample selection, the researcher chose one class, namely the Visual Communication Design (DKV) class X, consisting of 14 students, as the experimental class. This class was considered the most representative because it had learning characteristics that were close to the digital and visual world, so that the application of technology-based media such as flipbooks was deemed appropriate for their needs.

This study involved two types of variables, namely:

Independent Variable (X):

Mobile learning-based electronic modules in the form of digital flipbooks.

This variable is a factor that is thought to influence student learning outcomes. The treatment was carried out through the application of flipbooks in Informatics learning on Computer Systems material.

Dependent Variable (Y):

Student learning outcomes, namely the scores obtained by students after participating in learning using flipbook media. Learning outcomes were measured using pre-tests and post-tests compiled in the form of multiple-choice questions.

This study utilized two types of instruments, namely learning outcome tests and documentation. The learning outcome test served to assess students' cognitive abilities before and after the implementation of learning using flipbooks. The test instrument was compiled in the form of 20 multiple-choice questions with four answer options (a, b, c, d). Each correct answer received a score of 1, while incorrect answers received a score of 0.

The tests were administered twice:

Pretest (O_1): to identify improvements in learning outcomes before using the flipbook.

Posttest (O_2): to identify improvements in learning outcomes after using the flipbook.

Before use, the instruments were tested for validity and reliability. The validity test was used to ensure that the questions actually measured the competencies to be assessed, while reliability indicated the consistency of the measurement results. Furthermore, documentation techniques were used to collect secondary data, such as student attendance lists, test results, photos of activities, and other supporting documents such as lesson plans, student worksheets, and observation sheets. This documentation also served as authentic evidence of the research implementation.

Data collection was carried out through several steps, beginning with a pretest, implementation of treatment, posttest, documentation, and observation. The pretest

was conducted before learning began to identify students' initial abilities in computer systems. Treatment took the form of learning using electronic modules (flipbooks). Students were given the opportunity to study the material through flipbooks that could be accessed on their respective devices. The flipbook contained text, illustrations, animations, and interactive exercises. The teacher acted as a facilitator. After the learning was completed, students were given a posttest with a form and level of difficulty equivalent to the pretest to determine the optimization of learning outcomes after using the flipbook media. During the learning process, the researcher documented the activities through photos and observation notes to strengthen the quantitative data.

The data collected from the pretest, posttest, and supporting documentation were analyzed to assess the impact of the implementation of mobile learning-based electronic modules (flipbooks) in relation to student learning outcomes. Therefore, strict and precise data analysis procedures were applied so that the findings could be interpreted accurately and objectively, thus providing reliable evidence of the effectiveness of the modules in improving student learning achievement.

Data analysis was carried out in two consecutive stages, consisting of descriptive analysis and inferential analysis. Descriptive analysis was performed to provide a comprehensive illustration of student learning outcomes before and after the intervention, including minimum and maximum scores, mean, median, mode, range, and standard deviation. Then, inferential analysis was performed using t-tests and ANOVA with the help of SPSS version 26 to determine whether the difference between the pretest and posttest scores was statistically significant. Before the t-test was conducted, a normality test was first performed using the Kolmogorov–Smirnov test in SPSS version 26 to ensure that the data was normally distributed. This approach ensured the reliability and validity of the statistical inferences obtained from the study.

To classify student learning outcomes, the assessment guidelines from the Ministry of National Education (2023) were used with the following criteria:

Table 1. Learning Outcome Assessment Criteria

Score	Category
90 – 100	Very High
90 – 89	High
65 – 79	Moderate
55 – 64	Low
0 – 54	Very Low

Source: Ministry of National Education (2023)

Learning outcome assessment criteria are used to provide objective and standardized references for interpreting the scores achieved by students after going through the learning process. In the world of educational research in Indonesia, especially that oriented towards improving learning outcomes, these criteria serve to classify students' achievement levels based on the scores they obtain.

III. Findings and Discussion

A. Research Findings

1. Description of Research Results

This study was conducted at State Vocational High School 7 Bone, specifically in the Visual Communication Design (DKV) class X, which had a total of 14 (fourteen) students. This research is a pre-experimental design using a one-group pretest–posttest design. This means that the research only involved one experimental group without a control group. This research model was chosen because its main objective was to assess the effectiveness of using flipbook learning media in optimizing student learning outcomes in Informatics.

The research was conducted over six meetings. Each meeting was aimed at facilitating students in using mobile learning-based electronic flipbooks to understand Computer System material. This material was chosen because it has characteristics that require strong conceptual and visual understanding, which are often obstacles in conventional learning. The electronic flipbooks used were designed by integrating text, images, illustrations, and interactive quizzes that can be accessed through digital devices such as smartphones and laptops.

The main objective of this study is to analyze the differences and improvements in student learning outcomes before and after being given electronic flipbook learning media. To measure this, the researcher used a learning outcome test instrument, which was administered in two stages:

a. Pre-test: Conducted to identify the initial ability level of students before being given treatment or learning intervention.

b. Post-test: Conducted to identify the level of student ability after being given treatment or learning intervention.

Pre-test and post-test data were analyzed using SPSS version 26 to ensure accurate and reliable statistical results. The analysis included measures of central tendency (mean, median, and mode), measures of dispersion (standard deviation and range), and inferential statistical procedures, including normality tests and t-tests, to comprehensively evaluate the impact of the intervention on student learning achievement.

2. Descriptive Analysis

Descriptive analysis aims to represent students' learning outcomes in general before and after treatment using electronic flipbook learning media. The data used

was sourced from pre-test and post-test results of 14 (fourteen) students in the 10th grade Visual Communication Design (DKV) class.

a. Pre-test Data

In this study, a pre-test was used to assess students' prior knowledge and cognitive abilities before implementing the mobile learning-based electronic module (flipbook). This assessment involved 14 tenth-grade students majoring in Visual Communication Design (DKV) at State Vocational High School 7 Bone. The main objective was to evaluate students' initial understanding of the topic of Computer Systems in the Informatics subject. This evaluation tool contained 20 multiple-choice questions compiled in accordance with basic competency indicators and verified for validity and reliability. The pre-test was conducted in a controlled classroom setting before the start of flipbook-based learning to ensure that the results accurately reflected the students' initial cognitive competencies.

The results of the analysis show that:

Table 2. Data from the pre-test results of 10th grade DKV students at State Vocational High School 7 Bone.

Statistics	Value
Number of Samples	14
Lowest Value	30
Highest Value	65
Average	44
Range	35
Median	40
Frequently Occuring Values	30
Standard Deviation	13,07

Source: SPSS statistical processing version 26

Based on this data, it can be seen that students' pre-learning abilities are still at a minimal level. The average score of 44 (forty-four) indicates that most students have not mastered computer system material well before using electronic flipbook learning media. Most scores are below 65 (sixty-five), which is classified as low in the assessment category (Ministry of National Education, 2023).

This condition illustrates that students are not yet able to fully understand the abstract concepts that form the basis of Informatics learning, such as hardware components, software, and the relationship between the two in computer systems. The contributing factors may include low interest in learning, limited interactive learning media, and learning methods that are still dominated by conventional lectures.

b. Post-test Data

The post-test in this study was conducted after the entire series of learning using mobile learning-based electronic flipbook media had been completed for students in Grade X of the Visual Communication Design (DKV) Program at State Vocational High School 7 Bone. The post-test was conducted to evaluate the improvement in student learning outcomes after being given treatment using innovation-based learning media. Similar to the pre-test, the instrument used was an objective multiple-choice test consisting of 20 (twenty) questions covering all indicators of the Computer System material. The post-test questions had the same level of difficulty and material coverage as the pre-test so that the comparison between the two would be valid and objective. The test was conducted after six learning sessions using electronic flipbooks, which contained text, images, animations, and interactive quizzes to reinforce students' understanding.

Table 3. Data from the post-test results of 10th grade DKV students at State Vocational High School 7 Bone.

Statistic	Score
Number of Samples	14
Lowest Value	80
Highest Value	100
Average	85
Range	20
Median	85
Frequently Occuring Values	80
Standard Deviation	5,88

Source: Statistical processing using SPSS version 26

From these results, it can be seen that there was a significant increase in student learning outcomes. The average score increased from 44 (forty-four) for the pre-test to 85 (eighty-five) for the post-test. The highest score reached 100 (one hundred), while the lowest score was in the range of 80 (eighty), indicating that there were no students in the low or failing category. All students were in the “high” to “very high” categories.

These findings confirm that the use of electronic flipbooks can significantly improve students' mastery of computer system concepts. Flipbooks equipped with animations, visual illustrations, and interactive elements help students understand abstract material in a concrete and interesting way.

Comparison of Pre-test and Post-test

Visually, a comparison of the pre-test and post-test scores shows a clear improvement:

Average score increase = 85 – 44 = 41 points.

Percentage increase in learning outcomes = (41 / 44) × 100% ≈ 93%.

This condition shows an increase of almost double compared to the initial ability. The increase is not only quantitative, but also reflects changes in learning motivation, active participation, and student involvement during learning. The 93% (ninety-three percent) increase in scores is clear evidence that students have progressed in terms of knowledge, motivation, and involvement in the learning process. These findings reinforce that the implementation of mobile learning-based media—such as electronic flipbooks—is highly relevant in today's digital era, as it is able to address the challenges of learning that demand interactivity, flexibility, and the active involvement of students as a whole.

With these results, it can be concluded that the increase in scores is not merely the result of memorization or repetition of exercises, but a tangible manifestation of the transformation of the learning process into one that is more active, interesting, and meaningful. Electronic flipbooks have been proven to not only improve students' cognitive learning outcomes, but also shape independent, collaborative, and technology-based learning habits that are urgently needed in modern education systems.

3. Inferential Analysis

a. Normality Test

In this study, a normality test was conducted to assess whether the student learning outcome data, collected before and after the intervention using a flipbook-based electronic module, followed a normal distribution. Normality assessment is an important step because it is a prerequisite for the application of parametric statistical analysis, including the t-test, which is used to test the research hypothesis regarding the effectiveness of the intervention. The Shapiro-Wilk test was chosen because it is suitable for small samples. The analysis results showed that the pre-test data had a significance value of 0.029, while the post-test data was 0.006, both of which were below the conventional alpha level of 0.05. This indicates that the data did not fully follow a normal distribution. However, given the relatively small number of participants and limited deviation from normality, the paired t-test could still be applied. This was supported by the robust nature of parametric tests, which allow for reliable results even when minor assumptions are violated. Therefore, the t-test is considered an appropriate method for evaluating differences between pre-test and post-test scores,

so that statistical analysis can effectively support conclusions about the impact of flipbook-based mobile learning interventions on student learning outcomes.

Thus, the research data still meets the criteria for t-test, so that inferential analysis can be continued to test the significance of the impact of applying electronic flipbook media in strengthening students' understanding and mastery of the material.

b. Hypothesis Test

The hypothesis test in this study was designed to assess whether the application of mobile learning-based electronic modules (flipbooks) had a significant effect on students' learning outcomes in Informatics. T-tests were used for this purpose, as the study involved a single group—10th grade Visual Communication Design (DKV) students at State Vocational High School 7 Bone—who were assessed twice: before the intervention (pre-test) and after the intervention (post-test). This methodological approach allows for a direct comparison of student performance before and after using the flipbook, thus providing a strong measure of the effectiveness of the intervention. Data processing and analysis were performed using SPSS version 26 software to support the accuracy of the research results and ensure the level of accuracy and reliability of the evaluation. The paired t-test not only facilitated the determination of statistically significant differences but also provided empirical evidence supporting the conclusion regarding the effectiveness of mobile learning-based flipbooks as an innovative learning tool to improve students' understanding and academic achievement in the context of vocational secondary education.

The analysis results indicate a substantial increase in student learning outcomes after the implementation of mobile learning-based electronic modules (flipbooks). The average pre-test score was 44, which increased to 85 on the post-test, with an average difference of 41.43 points. Statistical analysis using a paired t-test yielded a t-value of -9.772 with 13 degrees of freedom and a two-tailed significance value of 0.000. Based on conventional significance criteria, because the p-value is less than 0.05, the statistical decision taken is to reject H_0 and accept H_1. This indicates a statistically significant difference between the pre-test and post-test results. These results confirm that the use of electronic flipbooks has a meaningful and measurable impact on students' academic achievement, highlighting their effectiveness as an innovative learning tool that can improve understanding, engagement, and overall achievement in computer science in the context of vocational secondary education.

B. Discussion

This study used a pre-experimental design involving one experimental class, namely 10th grade Visual Communication Design (DKV) students at State Vocational High School 7 Bone. The main objective of this study was to analyze the effect of mobile learning-based electronic modules in flipbook format on student learning

outcomes in Informatics, with a specific focus on Computer Systems material. By applying this approach, the study aimed to provide empirical evidence regarding the effectiveness of technology-integrated learning tools in improving student performance in a vocational education environment.

The background of this research stems from the urgent need to design a more interactive, adaptive, and contextual learning model. In practice, computer science learning in vocational high schools often faces various obstacles that limit learning effectiveness. These obstacles include limited availability of adequate learning media, low student engagement and motivation, and the dominance of teacher-centered pedagogical approaches, which can lead to a monotonous learning experience. This situation calls for innovation in learning strategies so that students can be more actively involved, the material taught becomes more interesting, and the learning process can be adjusted to the needs and characteristics of students in a more realistic manner.

To address these challenges, researchers developed a mobile learning-based electronic module in the form of an interactive flipbook, designed so that students can easily access it via smartphones or other mobile devices. This module was developed using the FlipHTML5 platform, a web-based application capable of converting static documents in PDF format into interactive digital books with multimedia features. In the module, researchers compiled learning materials on computer components, hardware, software, and how computer systems work, complete with illustrative images, video tutorials, and interactive quizzes. The module was developed in accordance with the independent vocational school curriculum, in which the basic competencies measured focus on the ability to understand, identify, and explain the functions and relationships between computer system components.

The flipbook module not only serves as the main learning resource during classroom learning, but can also be used independently by students. For easier access, the flipbook files are shared through the class WhatsApp group, so that students can study them without restrictions on time, location, or strong internet connection, as the flipbook can be downloaded and opened offline. This also supports the concept of mobile learning, which emphasizes flexibility and accessibility of learning in the digital age. With this medium, students have the opportunity to explore the material in a more in-depth and interactive manner, in line with the characteristics of 21st-century learners who are very familiar with digital technology.

During the study, students were first given a pre-test to measure their initial ability level before receiving treatment using electronic flipbooks. This pre-test consisted of 20 multiple-choice questions covering all aspects of Computer Systems material. From the data processing results, it was found that the average student pre-test score was 44, with a distribution of abilities showing that 64.3% were in the very low category, 28.6% were low, and 7.1% were moderate. None of the participants reached the high

or very high categories, reflecting their overall low initial abilities. These results illustrate that most students do not yet understand the basic concepts of computer systems, possibly because the previous learning process was still conventional and not very interesting for them.

After six learning sessions using flipbook-based electronic modules, the researchers then administered a post-test with the same number and level of difficulty of questions as those used in the pre-test. The results of the analysis showed a very significant increase in student learning outcomes. There were no longer any students in the low or very low categories; 71.4% of students were now in the high category (80–89) and 28.6% in the very high category (90–100). The average score increased dramatically from 44 (forty-four) on the pre-test to 85 (eighty-five) on the post-test, with an increase of 41 (forty-one) points. This increase not only illustrates an improvement in academic ability but also reflects changes in student behavior, interest, and participation during the learning activities.

Statistically, the increase in learning outcomes was tested using SPSS version 26. As an initial stage of analysis, a normality test was conducted on the pre-test and post-test data to verify the suitability of the distribution with the normal distribution, which is a prerequisite in parametric hypothesis testing. The findings from the Kolmogorov-Smirnov test indicated that the normality test produced a significance value of 0.104 for the pre-test and 0.042 for the post-test. According to the interpretation criteria, the data can be categorized as normal if the Sig. value exceeds 0.05. Therefore, the pre-test data meets the normality assumption, while the post-test data deviates slightly from the normal distribution. However, because the sample size is relatively small (n=14), this violation of the assumption is still tolerable and the t-test can still be performed, as this method is quite robust against minor violations of the normality assumption.

After the normality test was satisfied, the analysis continued with a Paired Sample T-Test to determine whether there was a significant difference between the values before and after treatment. The calculation results show that the Sig. (2-tailed) value is 0.000 < 0.05, so H_0 is rejected and H_1 is accepted. This means that there is a significant effect between the use of mobile learning-based electronic flipbook media and the improvement of student learning outcomes in Informatics. In other words, the application of electronic flipbooks has been empirically proven to have a significant positive impact on improving student learning achievement levels.

Theoretically, this finding supports Mayer's (2001) multimedia learning theory, which explains that the learning process becomes more effective when information is conveyed simultaneously through verbal and visual forms. In the context of this study, electronic flipbooks provide a combination of text, images, animations, and audio elements that complement each other in conveying abstract concepts about computer systems. This integration of multimodality helps students understand information more

easily and deeply, because the human brain tends to be better at processing information through two sensory channels at once.

In addition, these findings support constructivism theory, which emphasizes the active role of students in constructing their own understanding through direct experience, discovery, and self-reflection. In learning using flipbooks, students have the freedom to manage their learning time, choose the parts of the material they want to review, and do exercises independently. Thus, they are not just passive recipients of information, but are transformed into active learners who are responsible for their own learning process.

These findings are also consistent with various previous studies. For example, Saidah (2022) developed a mobile learning-based e-module and found a significant increase in students' research skills, indicating that digital media can encourage independent learning and improve academic outcomes. Minan's (2022) research also supports these results, finding that the use of Glide Apps-based e-modules is effective in vocational learning because it provides an interactive and contextual learning experience. Similarly, research by Utami, N., Gimin, G., & Riadi (2022) proved that the use of mobile learning as a learning medium had a positive impact on improving the academic achievement of high school students in the field of economics. Thus, the research conducted at State Vocational High School 7 Bone strengthens the empirical evidence that interactive digital learning media such as electronic flipbooks are highly effective in improving learning outcomes at various levels of education and fields of study.

The success of improving student learning outcomes in this study can be explained by several interrelated factors that contribute to the effectiveness of learning. The first factor is the active involvement of students during the learning process. Electronic flipbooks encourage students to not only read the material, but also interact with the content presented through animations, videos, and interactive quizzes. This interaction makes the learning process more enjoyable and meaningful, while also strengthening long-term memory of the concepts that have been learned.

The second factor is the presentation of interesting and visual material. The visual design in flipbooks plays an important role in overcoming learning fatigue, especially among vocational school students who prefer visual and practical-based learning. The combination of text with images and animations makes abstract concepts such as how computer systems work more concrete and easier to understand. This visual presentation also helps students with visual or kinesthetic learning styles to master the material more easily.

The third factor that has a significant impact is student independence in learning. Because flipbooks can be accessed via mobile devices, students have the freedom to learn anytime and anywhere without having to wait for explanations from teachers. This greatly supports the concept of self-directed learning, which is the ability of

students to organize, monitor, and evaluate their own learning process. This ability is one of the important indicators of 21st-century competencies needed in modern education and the workplace.

The fourth factor is the role of teachers as learning facilitators. Although digital media gives students the freedom to learn independently, the role of teachers remains very important in providing direction, motivation, and guidance. Teachers act as guides so that students can use learning media effectively and not be distracted by irrelevant technology. In this context, teachers apply the principle of Technological Pedagogical Content Knowledge (TPACK), which is the ability to integrate aspects of technology, pedagogy, and learning content in a balanced manner to create a meaningful and effective learning experience.

Although the results of the study show high effectiveness, the implementation of learning using electronic flipbooks is not without several obstacles. One of the main obstacles faced is the limitation of digital devices among some students. Not all students have smartphones with sufficient storage capacity or stable internet connections, so some students have difficulty accessing the modules optimally. In addition, the uneven level of digital literacy among students is also a challenge. Some students are still unfamiliar with using digital platforms for academic purposes, so initial guidance from teachers is needed. Another influencing factor is the stability of the internet network, especially for students who live in areas with limited technological infrastructure.

From a pedagogical perspective, the effectiveness of electronic flipbooks also depends heavily on student motivation. Engaging digital media does not necessarily guarantee high learning outcomes if students lack intrinsic motivation to learn. Therefore, the success of technology-based learning such as this needs to be supported by motivational strategies from teachers, such as providing positive feedback, rewards, and continuous guidance.

Overall, research data shows that the use of mobile learning-based electronic flipbooks contributes significantly to improving students' understanding and learning achievement in the field of Informatics. This medium not only improves cognitive aspects in the form of increased academic grades, but also enhances affective aspects such as motivation, interest, and student confidence in learning. The learning experience becomes more enjoyable, interactive, flexible, and tailored to the needs of students in the digital age.

However, this study has methodological limitations, namely that it did not use a control group for comparison. The one-group pretest–posttest design can only show an increase after treatment, but cannot confirm that the increase was solely due to the use of flipbooks. External factors such as learning environment conditions, family support, or individual motivation may also have contributed to the results. Therefore, the researchers recommend that further research use a quasi-experimental or true-

experimental design with two groups (experimental and control) so that the results obtained are more accurate and can be generalized more broadly.

Conceptually, this study makes a real contribution to the development of digital learning media in vocational schools, while also emphasizing that the integration of technology in the teaching and learning process is not just a trend, but an important necessity for creating adaptive learning that is relevant to the times.

IV. Conclusion

The results of the study prove that the use of mobile learning-based electronic modules in flipbook format is effective in improving the learning outcomes of 10th grade Informatics students at State Vocational High School 7 Bone. The average score of students increased significantly from 44 on the pre-test to 85 on the post-test, indicating meaningful progress in learning achievement.

Statistical analysis using the t-test yielded a significance value of 0.000, indicating that the difference between the scores before and after the intervention was statistically significant. This confirms the effectiveness of the mobile learning-based module. Thus, the research hypothesis is supported, showing that mobile learning-based electronic modules have a positive and measurable impact on students' understanding and mastery of Informatics concepts. These findings emphasize the potential of technology-integrated learning tools, such as flipbook modules, to encourage active engagement, enhance cognitive development, and improve overall academic achievement in the context of vocational education.

This improvement not only reflects success in cognitive aspects but also indicates positive changes in students' motivation, interest, and learning independence.

The flipbook media developed is capable of creating an interactive, engaging, and flexible learning experience because it can be accessed anytime via mobile devices. Multimedia features such as text, images, videos, and interactive quizzes make the learning process more lively and enjoyable, and help students understand IT concepts that were previously difficult to grasp through conventional methods.

From a pedagogical perspective, these findings imply that the use of digital technology in the learning process can be a strategic alternative to improve learning effectiveness in the digital age, especially in vocational high schools that require technological skills. The results of this study also show that innovations in mobile learning-based learning media are in line with the demands of the Merdeka Belajar (Independent Learning) curriculum, which emphasizes independence and flexibility in learning. Thus, teachers need to continue to develop their digital competencies in order to be able to create learning that is relevant and contextual to the characteristics of today's students.

The practical implications of this study emphasize the importance of school support in providing technological infrastructure such as internet networks, digital devices, and teacher training so that mobile learning can be implemented optimally. In addition, students are expected to be more active and independent in utilizing digital media as a learning tool, thereby developing the critical thinking, creativity, and digital literacy skills needed in the modern workplace. This study also contributes theoretically to the field of educational technology by strengthening empirical evidence that mobile learning is effective in improving student learning outcomes and motivation.

Recommendations for future researchers include expanding the scope of research by involving a larger sample, adding a control group to strengthen the validity of the results, and developing mobile learning-based learning models or products that can be applied to various other subjects. Overall, this research proves that the use of mobile learning-based electronic modules is not merely an innovation in learning media, but also a strategic solution in the transformation of education towards a more adaptive, modern learning system oriented towards the development of students' digital competencies in the 21st century.

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