Development of a smart apps creator-based e-book to enhance students' conceptual understanding and digital literacy

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Article History
Received: 10 December 2024
Revised: 7 March 2025
Accepted: 10 June 2025

Keywords
Concept understanding
Digital literacy
E-book
Measurement
Smart apps creator

Abstract
This study aims to develop a Smart Apps Creator-based e-book that is feasible and effective for use in learning the topic of measurement in Grade 10 high school. In addition, this study aims to determine the improvement of students' conceptual understanding and digital literacy after using the physics e-book developed with Smart Apps Creator. The method used in this research is Research and Development (R&D) using the 4D development model. Data collection techniques in this study included non-test instruments such as observation and questionnaire sheets, as well as a 27-item multiple-choice test on the measurement topic. The results showed that: (1) The e-book learning media based on Smart Apps Creator is suitable for use in learning the topic of measurement for Grade 10 high school students, with the category "Very Good"; (2) The e-book learning media based on Smart Apps Creator can improve students' conceptual understanding (N-gain = 0.75) with the category "High"; (3) The Smart Apps Creator-based e-book learning media can improve students' digital literacy (N-gain = 0.58) with the category "Upper Medium"; and (4) The Smart Apps Creator-based e-book learning media is effective for learning the topic of measurement to enhance students' conceptual understanding and digital literacy.

Diyana, T. N., & Artanti, F. H. (2025). Development of a smart apps creator-based e-book to enhance students' conceptual understanding and digital literacy. *Momentum: Physics Education Journal*, *9*(2), 275-285. https://doi.org/10.21067/mpej.v9i2.11106

1. Introduction

Physics is one of the subjects that many students find difficult to understand. According to Ningrum et al. (2023), physics learning is not limited to learning concepts, applying those concepts to solve physical problems, or conducting scientific research. However, many students become reluctant to learn physics. Research by Anggraeni et al. (2021) states that one of the factors causing low student interest in learning physics is that many teachers have not utilized learning media that can attract students' interest. This is partly due to teachers lacking the knowledge and skills needed to use learning media, which results in a boring learning experience. This situation is certainly not in line with the objectives of the curriculum in force in Indonesia, namely the Kurikulum Merdeka. In implementing the curriculum, teachers play a very important role. As facilitators, teachers must not only understand concepts but also be able to apply them effectively in the learning process. In addition, the selection of learning models significantly influences the physics learning process (Talib & Amiroh, 2022). One learning model suitable for curriculum implementation is discovery learning.

Discovery learning actively engages students in the learning process, requiring them to explore and discover concepts independently (Marisya & Sukma, 2020). However, in reality, this learning model is still rarely applied. This is supported by research from Fitriani et al. (2021), which states that many teaching methods appear monotonous and unengaging. Moreover, research findings show that students' understanding of quantities, units, and measurement materials falls into the "medium" category, indicating the need for improvement in their grasp of physics concepts, particularly in measurement topics.

Measurement is a fundamental concept in physics and serves as a foundation for studying other physics topics. However, in practice, teachers often focus only on formulas without explaining the underlying physics concepts, leading to students' lack of interest in learning. Research by Alrizal et al. (2023) found that 60.6% of students reported difficulty in understanding measurement concepts.

doi: 10.21067/mpej.v9i2.11106

ISSN: 2548-9135

In physics learning, students should not only memorize theories and formulas but also develop a deeper understanding of concepts and their applications (Perdana et al., 2017).

Currently, students' concept mastery remains low. Andriani (2023) found that students' understanding of measurement topics is still inadequate. This is supported by an analysis of daily test results, which revealed that only 50% of students scored above the minimum competency threshold. Conceptual understanding is not merely about recalling information but also involves the ability to apply learned concepts and solve related problems. It serves as a benchmark for assessing students' comprehension and mastery of the material.

Research has shown that concept mastery is closely related to digital literacy skills. Students with higher digital literacy tend to have a better understanding of concepts and key ideas. Digital literacy is defined as the ability to search, evaluate, analyze, and utilize digital technology effectively (Suminarsih, 2023). However, digital literacy in physics learning remains low. One contributing factor is that educators rarely incorporate literacy-based questions or optimize digital learning materials, largely due to a lack of awareness about the importance of digital literacy in education. Schools also play a crucial role in facilitating digital-based learning to enhance the overall learning experience.

To support the learning process, interactive learning media are essential. Developing digital learning media is one possible solution to these challenges. One effective digital learning tool is e-books. E-books are digital versions of traditional books that can be accessed through devices such as computers, laptops, smartphones, or tablets (Irawan et al., 2024). One software that can be used to create e-books is Smart Apps Creator. Smart Apps Creator is a software application that enables users to develop multimedia features for mobile, desktop, and web platforms (Susanti et al., 2021). Additionally, it allows users to create mobile applications for Android and iOS without requiring programming skills (Khasanah & Rusman, 2021).

Previous research on the development of Smart Apps Creator-based learning media for the measurement topic was conducted by Komariah et al. (2022). The study used a 4D development model, but due to time constraints, the research only reached the 3D stage. Furthermore, the study primarily evaluated media feasibility without assessing its effectiveness in enhancing students' conceptual understanding. Another study on Smart Apps Creator-based learning media was conducted by Watin et al. (2023). This research also employed the 4D model, but the dissemination phase was limited to a single class of 26 students. The study concluded that Smart Apps Creator-assisted physics learning media on mechanical wave characteristics is valid, reliable, effective, and practical for improving students' conceptual understanding.

Based on the issues described above, there is a need to develop learning media that can enhance students' understanding of measurement concepts. This study aims to develop a Smart Apps Creator-based physics e-book that is suitable for use in teaching measurement topics to Grade 10 high school students. Additionally, this research seeks to improve students' conceptual understanding and digital literacy skills, particularly in physics measurement topics. Furthermore, this study aims to evaluate the effectiveness of the Smart Apps Creator-based physics e-book in enhancing students' conceptual understanding and digital literacy in Grade 10 high school physics learning.

2. Method

This research uses the research and development (RnD) method with the 4D model, which is divided into four stages: define, design, develop, and disseminate. The define stage aims to determine, collect, and analyze the various information needed for the research. The design stage aims to create an initial description of the media product to be developed. The develop stage is carried out to produce a final product that is effective and ready to use. This stage aims to develop e-book learning media that have been revised based on suggestions and comments from expert lecturers and practitioners. The last stage is the disseminate stage, which aims to disseminate the developed products in the form of Smart Apps Creator-based e-books.

This research design consists of two groups, each of which receives pretest and posttest assessments to measure the improvement in concept understanding and is also given a digital literacy questionnaire. This research involves giving a treatment using the e-book learning media

developed for the experimental group, while the control group uses learning media in the form of PowerPoint as a comparison.

Data collection techniques in this study include non-test instruments, such as observation and questionnaire sheets, as well as test instruments in the form of pretests and posttests. This study utilizes learning instruments that consist of teaching modules or lesson plans designed with discovery learning syntax and Smart Apps Creator-based e-book learning media. Data collection instruments include pretest and posttest questionnaires, digital literacy questionnaires, student response questionnaires on the media, and learning implementation observation sheets. Before being used in research, these instruments undergo feasibility assessment through an instrument feasibility sheet. This sheet is used to obtain validation results from expert and practitioner validators.

After being declared valid, the instrument was then used for a limited trial. The student response questionnaire was then analyzed using the SBi analysis technique. Meanwhile, the digital literacy questionnaire and pretest and posttest questions were analyzed using the QUEST program. A digital literacy questionnaire item and pretest or posttest question is declared valid if its INFIT MNSQ value falls within the range of 0.77 < INFIT MNSQ < 1.33. In the limited trial, the results of the pretest and posttest were analyzed for validity, reliability, and item functioning using the QUEST program. This study included 30 questions, of which 3 had INFIT MNSQ values outside the interval (0.77–1.33), making them invalid, while the other 27 fell within the interval and were declared valid. For the reliability test, the summary of item estimates was 0.84, which falls into the very high or very reliable category.

Furthermore, the digital literacy questionnaire was also analyzed for validity and reliability using the QUEST program. The results showed that all items in the questionnaire had INFIT MNSQ values within the interval (0.77–1.33), meaning they were declared valid. For the reliability test, the summary of item estimates was 0.63, placing it in the high or reliable category.

After undergoing the revision process, the entire instrument was then used for a broad trial in research. In this phase, the learning implementation sheet was analyzed using the Interjudge Agreement (IJA) technique. This analysis assessed how well learning activities aligned with the planned teaching module. The IJA analysis was calculated using the following formula (Eq. 1):

$$IJA = \left\{\frac{A_y}{A_y + A_N}\right\} \times 100\% \quad (1)$$

with:
A_y : Activities carried out
A_N : Activities that were not carried out

There are several data analysis techniques used in this study, one of which is the Ideal Standard Deviation (SBi) which is used to test the feasibility of the instrument. SBi analysis assessment criteria are presented in Table 1.

Table 1. Analysis Result Criteria

Range Score	Category
$(\bar{x}_i + 1{,}5\ SBi) < x < (\bar{x}_i + 3\ SBi)$	Very Good
$\bar{x}_i < x \leq (\bar{x}_i + 1{,}5\ SBi)$	Good
$(\bar{x}_i - 1{,}5\ SBi) < x \leq \bar{x}_i$	Not Good
$(\bar{x}_i - 3\ SBi) < x \leq (\bar{x}_i - 1{,}5\ SBi)$	Very Unfavorable

(Lukman & Ishartiwi, 2014)

The improvement of concept understanding and digital literacy skills was analyzed using gain analysis. This analysis was carried out by looking at the results of students' pretest and posttest scores and digital literacy questionnaires before and after learning. The increase in concept understanding and digital literacy analyzed by gain analysis and using the following equation (Eq. 2):

$$g = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \quad (2)$$

The criteria for increasing the measured variables (Table 2) will be classified with the following reference:

Table 2. Standard Gain Value Criteria

g value	Criteria
$0{,}65 \leq g$	High
$0{,}45 \leq g < 0{,}65$	Upper Medium
$0{,}25 \leq g < 0{,}45$	Lower Medium
$g < 0{,}25$	Low

(Sutopo & Waldrip, 2014)

Then to determine the effectiveness of the product developed, a prerequisite test is carried out, namely the normality test and homogeneity test with the help of the IBM SPSS Statistics 25 program. After the data is declared normal and homogeneous, then a paired sample t-test is carried out to determine the difference in giving average treatment to two groups that are paired with each other on the ability to master concepts and digital literacy. After that, it was continued with the manova test to determine the difference in the improvement of concept understanding ability and digital literacy between the control class and the experimental class. Furthermore, the effect size analysis was carried out. The effect size shows how much influence the developed media has on improving students' mastery of physics concepts and digital literacy. The effect size test is calculated using Cohen's d (standardized mean difference) with the following equation (Eq. 3 & Eq. 4):

$$Cohen's\ d = \frac{M_1 - M_2}{SD_{pooled}} \quad (3)$$

with:

$$SD_{pooled} = \sqrt{\frac{{SD_1}^2 + {SD_2}^2}{2}} \quad (4)$$

M_1 : average value of experimental class posttest questions
M_2 : average value of control class posttest questions
SD_{pooled} : pooled standard deviation
SD_1 : standard deviation of experimental class
SD_2 : standard deviation of control class

From the criteria (Table 3) that have been presented, the effect size can be categorized at the following levels:

Table 3. Effect Size Category (Cohens'd)

$\boldsymbol{Effect\ Size\ (ES)}$	Criteria
$0{,}8 < ES$	Very Large
$0{,}5 < ES \leq 0{,}8$	Large
$0{,}2 < ES \leq 0{,}5$	Medium
$0 < ES \leq 0{,}2$	Small

Wahyu Ariyani & Prasetyo (2021) in Luthfianingrum (2024:5)

3. Results and Discussion

3.1. Development of an e-book based on smart apps creator

In the first stage, namely the define stage, literature reviews, interviews, and observations were carried out. This stage consists of several types of analyses, namely the preliminary analysis, which aims to obtain information about the physics learning process. From the preliminary analysis, the results showed that the learning process had not made optimal use of digital media. In addition, the learning process was still teacher-centered. Then, after the preliminary analysis, the next step was analyzing students' characteristics, which revealed that many students still perceived physics as a difficult and boring subject, making them less interested in learning it. This was followed by task

analysis, which aims to determine the content of learning materials; concept analysis, which aims to identify concepts from the results of task analysis; and the analysis of learning objective specifications.

The second stage, namely the design stage, consists of four steps. The first step is determining the media to be used in the research, which in this case is an e-book based on Smart Apps Creator. The next step is choosing the format best suited to the media being developed. Following this, the initial design of the product was created in the form of an e-book that includes the front page, main menu, instructions for use, general information menu, concept map menu, and learning activities menu, which contains learning materials, learning activities, quizzes, and a bibliography menu. In addition to designing the e-book, this stage also produced a draft of the research instrument to be used. The design of the e-book based on Smart Apps Creator can be seen in Figure 1.

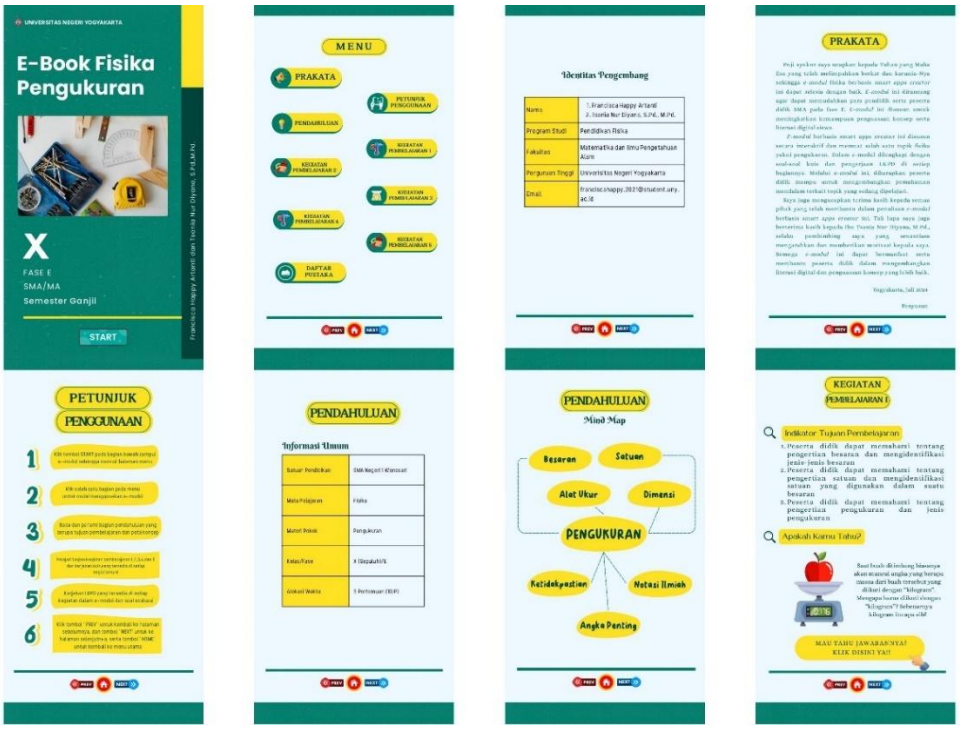

Figure 1. E-Book based on Smart Apps Creator

The third stage or development stage begins with the validation stage of research instruments conducted by expert validators and practitioners. The instruments assessed were teaching modules, Smart Apps Creator-based e-book learning media, pretest and posttest questions, digital literacy questionnaires, and student response questionnaires to the media. The results are in Table 4.

Table 4. Instrument feasibility validation test results

No	Instrument	Average Score	Category
1	E-book based on Smart Apps Creator	3.61	Very Good
2	Teaching Module	3.26	Very Good
3	Digital Literacy Questionnare	3.61	Very Good
4	Learner Response Questionnare	3.67	Very Good
5	Pretest and Posttest Questions	0.99	Very Valid

The feasibility assessment of the e-book based on Smart Apps Creator, the teaching module, the digital literacy questionnaire, and the learner response questionnaire was analyzed using the Ideal Standard Deviation (SBi) method, while the pretest and posttest questions were analyzed using Aiken's V method. The analysis results showed that all research instruments fell into the "excellent" category, which means that all research instruments developed were suitable for use in a limited test study. Before the limited test, the research instruments were revised based on the validators' comments and suggestions.

After the define, design, and develop stages were carried out, the last stage was the disseminate stage, which aimed to distribute the developed products. The e-book based on Smart Apps Creator was then distributed to physics teachers and students at the school where this research was conducted.

In addition to the stages previously mentioned, this study also had several research limitations. The e-book developed was still limited to the topic of measurement only, so further development is needed for other physics topics. Additionally, this e-book can only be accessed using an Android smartphone, which prevents iOS users from accessing it. Furthermore, it is necessary to optimize the application so that the e-book's file size is reduced, ensuring that the installation process does not take too long.

3.2. Results of students' response to the e-book

The feasibility of the e-book based on Smart Apps Creator was analyzed based on the results of learner responses collected during both limited and broad trials. Additionally, the feasibility of the e-book was assessed using the student response questionnaire. The data obtained were then analyzed using the Ideal Standard Deviation (SBi) method. For this assessment, a questionnaire instrument with a 4-point scale was used, consisting of three aspects with 20 statement items. In the limited test, the results of the student response questionnaire showed an average score of 3.25, which falls into the "very good" category. This indicates that the developed e-book is suitable for use in a broad trial. In the broad trial, the results of the analysis of students' responses to the media are presented in Table 5.

Table 5. Results of E-Book Feasibility

No	Aspect	Score	Criteria
1	Display	3.20	Good
2	Content	3.40	Very Good
3	Languange	3.35	Very Good
Average		3.32	Very Good

The results of the analysis of the students' response questionnaire to the e-book media showed an overall average score of 3.32. Based on the categorization in the table above, a score of 3.32 falls into the "very good" category. Thus, the Smart Apps Creator-based e-book developed in this study is suitable for use in learning. This finding aligns with previous research conducted by Yuberti et al. (2021), which stated that Smart Apps Creator-based learning media are suitable for use in SMA/MA physics learning. Similarly, another study conducted by Komariah et al. (2022) found that Android-based interactive learning media using Smart Apps Creator (SAC) for measurement material are feasible for use by students in the learning process.

3.3. The improvement of students' concept understanding

The increase in students' concept understanding ability can be seen from the N-Gain value of pretest and posttest questions on a broad trial. The questions used in the broad trial have gone through several processes including feasibility tests and limited trials. In the broad trial, the questions consisted of 27 items which originally amounted to 30 items and had undergone improvements. The results of the analysis of the improvement of students' concept understanding ability can be seen from Table 6 & Figure 2.

Table 6. Results of improvement in concept understanding

Class	Pretest	Posttest	N-Gain	Category
Experimental	30.44	80.89	0.73	High
Control	39.83	69.56	0.49	Upper Meedium
Average			0.61	Upper Medium

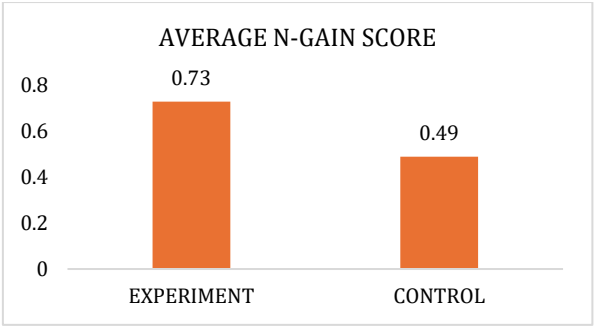

Figure 2. Graph of concept understanding improvement results

The analysis of the students' conceptual understanding improvement is presented in Table 6, and the corresponding improvement graph is shown in Figure 1. Both indicate that the pretest score of the experimental group had an average value of 30.44, while the control group had an average value of 39.83. This suggests that the initial conceptual understanding of students in the control group tended to be higher than that of the experimental group. After undergoing instruction with different treatments, a posttest was administered. The results showed that the average posttest score of the experimental group was higher than that of the control group. During instruction, the experimental group used an E-Book based on Smart Apps Creator as a learning medium, with a posttest average score of 80.89 and an n-gain value of 0.73, which falls into the high category. Meanwhile, the control group, which used PowerPoint as a learning medium, obtained a posttest score of 69.56 with an n-gain value of 0.49, placing it in the upper-medium category. Thus, the Smart Apps Creator-based e-book is effective in improving students' conceptual understanding. This finding aligns with research by Amalia et al. (2022), which states that Smart Apps Creator-based learning media is effective in enhancing students' conceptual understanding, as evidenced by an average N-Gain value of 0.7.

3.4. The improvement of students' digital literacy

In addition to improving conceptual understanding, this study also conducted research to determine the improvement of students' digital literacy skills assessed from a digital literacy questionnaire. The digital literacy questionnaire has 20 statements that have previously gone through several stages. The first stage is feasibility testing by validators and the second stage is a limited trial. The results of the analysis of the improvement of students' digital literacy in the control and experimental classes can be seen in Table 7& Figure 3.

Table 7. Results of improvement in digital literacy

Class	Pretest	Posttest	N-Gain	Category
Experimental	2.87	3.52	0.58	Upper Medium
Control	2.67	3.06	0.29	Lower Medium
Average			0.43	Lower Medium

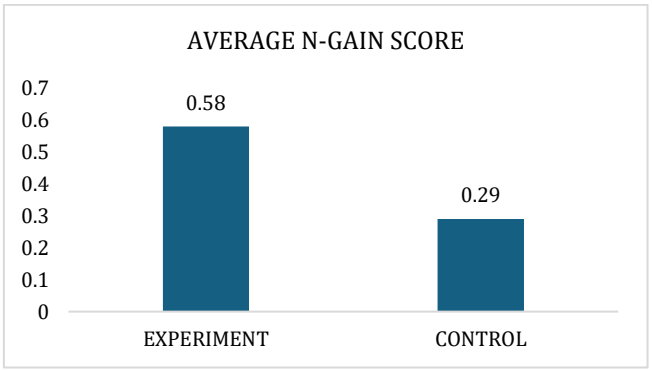

Figure 3. Graph of digital literacy improvement results

The results of the analysis of the students' digital literacy improvement are presented in Table 7, and the corresponding improvement graph is shown in Figure 2. Both indicate that learners in the

control and experimental groups had relatively similar initial digital literacy skills. This is supported by the initial average digital literacy scores, which were 2.87 for the experimental group and 2.67 for the control group. After the learning process, a digital literacy questionnaire was administered again, and the results revealed that the digital literacy skills of the experimental group were significantly higher. In the experimental group, which used Smart Apps Creator-based e-books, the average score was 3.52, with an n-gain value of 0.58, which falls into the upper-medium category. Meanwhile, the control group, which did not use e-books, had an average score of 3.06, with an n-gain value of 0.29, placing it in the lower-medium category. Thus, the Smart Apps Creator-based e-book is effective in improving students' digital literacy. This finding aligns with research by Anggrasari (2020), which states that the use of e-learning has been proven to enhance digital literacy skills. Additionally, the use of e-books in learning is recognized as one of the creative solutions to improve digital literacy (Irawan et al., 2024).

3.5. The effectiveness of using e-book based on smart apps creator

To determine the effectiveness of the media developed, a prerequisite test is carried out first. The prerequisite tests in question are normality test and homogeneity test. Data is said to be normally distributed if the significance value obtained is > 0,05, while the data is not normally distributed if the significance value is < 0,05. From the normality test results presented in this study, it shows that the increase in concept understanding in the experimental class and control class has a significance value of 0.200. The significance results in the experimental class and control class have a significance value ≥ 0,05. As for the improvement of digital literacy in the experimental class, the significance value is 0.200 and the control class has a significance value of 0.110. The significance results in the experimental and control classes have a significance value ≥ 0,05, so the data on improving concept understanding and digital literacy are normally distributed.

The homogeneity test was carried out using IBM SPSS 25 software. One of the statistical tests used is the Levene Test. The criterion used is if the significance value ≥ 0,05 hen the data is assumed to be homogenized, but if the significance < 0,05 then the data is assumed to be inhomogenized. Based on the results of the homogeneity test in this study, it states that the significance value on the concept understanding variable is 0.082. While the significance value on the digital literacy variable is 0.150. This shows that the significance value of concept understanding and digital literacy ≥ 0,05. Thus, the data of concept understanding and digital literacy are declared homogenized.

The data that has been declared normally distributed and homogenized, then continued with the paired sample t-test. This analysis test aims to determine the difference in giving the average treatment of two groups that are paired with each other on the ability to master concepts and digital literacy. The results of the paired sample t-test are presented in Table 8.

Table 8. Result paired sample t-test

	Class	Mean	Significance
Conceptual understanding	Experimental	-50.444	0.000
	Control	-29722	0.000
Digital Literacy	Experimental	-13.083	0.000
	Control	-7.722	0.000

The results in Table 8, show the significance value on the concept understanding variable of the experimental class and control class is 0.000. Both have a significance value < 0,05. This shows that the pre-test and posttest values of concept understanding have significant differences or have increased in both control and experimental classes. While in the digital literacy variable, the significance value in the experimental class and control class is 0.000. Where both have a significance value < 0,05. This shows that the initial ability of students' digital literacy and the final ability of students' digital literacy have significant differences or have increased in both control and experimental classes.

Furthermore, the data that has gone through the prerequisite test process and has met the requirements is continued with the manova test. The manova test aims to determine whether there is a difference in the dependent variable between several different groups. The results of the manova test are presented in Table 9.

Table 9. Manova test (test of between-subject effect)

Test of Between-Subject Effect	
	Significance
Conceptual Understanding	0.000
Digital Literacy	0.000

Based on the results of the MANOVA analysis in Table 9, it can be seen that the significance value for the variables of concept mastery and digital literacy is 0.000. This indicates that there are significant differences in the improvement of conceptual understanding and digital literacy between the experimental group, which used an E-Book based on Smart Apps Creator, and the control group, which used PowerPoint as a learning medium. Furthermore, a hypothesis test was conducted using the Multivariate Test in the MANOVA procedure.

The results of the Multivariate Test show that the Wilks' Lambda test yielded a significance value of 0.00. This confirms that there are significant differences in the improvement of conceptual understanding and digital literacy between students who used the Smart Apps Creator-based E-Book and those who did not, specifically on the topic of measurement. After conducting the MANOVA test, an effect size analysis was carried out to determine the extent of the impact of the Smart Apps Creator-based E-Book on students' mastery of physics concepts and digital literacy. The effect size analysis was performed by comparing the average posttest scores of students who used the E-Book with those who did not.

From the analysis, the effect size of using the Smart Apps Creator-based E-Book on students' conceptual understanding was found to be 0.55, which falls into the large category. Similarly, the effect size for students' digital literacy skills was 0.51, also classified as large. These results indicate that the Smart Apps Creator-based E-Book is effective in enhancing students' conceptual understanding and digital literacy. Thus, it can be concluded that the product developed in this study, namely the Smart Apps Creator-based E-Book, has a significant impact on improving students' mastery of concepts and digital literacy.

This finding is consistent with research by Mahuda et al. (2021), which states that Android-based learning media assisted by Smart Apps Creator is effective in learning. This is further supported by research conducted by Uspayanti & Pandiangan (2023), which shows that the use of e-books as learning media can enhance students' digital literacy skills. Similarly, a study by Watin et al. (2023) also found that physics learning media assisted by Smart Apps Creator was effective in improving students' conceptual understanding. This conclusion is supported by their findings, which indicate that students' conceptual understanding improved, as evidenced by an average N-Gain of 0.8, classified as high.

4. Conclusion

Based on the results of the study and discussion, it can be concluded that the Smart Apps Creator-based E-Book developed in this research is suitable for use in teaching the measurement topic for Grade X high school (SMA) students, with a "Very Good" category rating. The Smart Apps Creator-based E-Book can enhance students' conceptual mastery in the "High" category and improve students' digital literacy in the "Upper Medium" category. The findings also indicate that the Smart Apps Creator-based E-Book is effective for use in teaching the measurement topic. However, one of the limitations of this study is that the developed material is limited to the measurement topic only. Therefore, future researchers are encouraged to expand the E-Book to cover additional topics. Furthermore, it is recommended that future studies develop multiple versions of the E-Book to ensure optimal accessibility for all students.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

No funding support was received.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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