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Physics E-Book Using Indigenous Instruments to Foster Critical Thinking and Digital Literacy

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Abstract

This study develops a physics e-book integrating Indigenous Instruments (*Kacaping* and *Puik-puik*) to foster students' critical thinking and digital literacy, and evaluates its feasibility and effectiveness in learning. The research adopts the Research and Development (R&D) method with the ADDIE model to design the learning product. The subjects were Class XI MIPA students at SMAN 9 Makassar, using a pretest-posttest control group design with two experimental classes and one control class. Data were collected through observation, interviews, tests, and questionnaires, while instruments included student response questionnaires, critical thinking, and digital literacy tests. Instrument validation employed Aiken's V, and empirical testing used Quest software. Product effectiveness was analyzed using GLM (General Linear Model). The results indicate that the developed e-book on sound wave material is valid in terms of media and content, and limited trials demonstrated its ability to enhance critical thinking and digital literacy. MANOVA analysis further confirmed its effectiveness. Integrating *Kacaping* and *Puik-puik* not only contextualizes physics learning culturally but also provides an engaging and meaningful approach, supporting both cognitive skills and digital competence.

Keywords: critical thinking, digital literacy, google sites, local instruments, physics e-book

INTRODUCTION

Learning in the twenty-first century enables connections between science and the real world through critical thinking. Critical thinking ability helps students understand the information presented in learning (Damayanti & Kuswanto, 2021). Critical thinking ability is a crucial skill in the industrial era 4.0, which requires humans to act and make decisions appropriately and quickly (Aurum & Surjono, 2021). Critical thinking enables individuals to make informed decisions and form beliefs by analyzing problems and drawing logical conclusions (Sulardi, Nur, & Widodo, 2015). Low critical thinking abilities are often attributed to the teacher-centered learning process, which can cause students to become passive and fail to understand the learning material (Munandar, Sutrio, & Taufik, 2018). Learning that does not involve students actively tends to make students accustomed to using a small portion of their potential thinking abilities and being lazy to think (Latifah, Ashari, & Kurniawan, 2020). Critical thinking ability can be combined with the knowledge gained by students, making it useful for their future lives.

Students still lack critical thinking ability in the learning process. This can be seen from the indicators of students' critical thinking abilities who are unable to fulfill the indicators of analyzing, evaluating, and inferring (Purwati, Hobri, & Fatahillah, 2016). The learning outcomes of students with high critical thinking abilities are better than those of students with low critical thinking abilities

(Heidari, 2020). Critical thinking ability can change inactive students into active in the learning process (Li & Heydarnejad, 2024). Critical thinking ability is not a natural ability that students possess, so it must be developed directly in the learning process (Zare, Barjesteh, & Biria, 2021). Therefore, critical thinking ability is crucial for enhancing learning.

Physics learning can be understood with students' critical thinking ability. The aim of learning physics in school is to enhance the ability to think creatively, critically, and collaboratively, so that students are capable and able in the cognitive field. (Khoiri, Ristanto, & Kurniawan, 2023). Critical thinking ranks first and is considered a requirement for successful mastery of physics learning material (Wenno, Limba, & Silahoy, 2022). Critical thinking ability can be applied in physics learning, particularly when material utilizes audio and visual aids, such as sound waves (Slisko, 2021). Apart from that, sound wave material contains many similarities that make students less likely to understand just by reading without involving critical thinking ability (Maulida, Prihandono, & Maryani, 2019). The average value of sound wave material on critical thinking ability based on the indicator of giving a simple explanation, which was obtained at 27.6%, the concluding indicator obtained at 57.6%, and the strategy and technique indicator obtained at 35.6% (Suganda, Parno, & Sunaryono, 2020). Physics concepts in sound wave materials should be understood more meaningfully, which can encourage students to think critically (Rahmat, Kuswanto, Wilujeng, & Pratidhina, 2023). Sound wave material is very important to understand by increasing students' critical thinking ability.

Technological advances must be optimized in learning by integrating literacy skills, knowledge, abilities, and attitudes, as well as mastery of technology. Learning efficiency and effectiveness can be enhanced by utilizing information and communication technology, thereby providing students with a maximized learning experience (Anggraeni & Sole, 2018). The use of technology in learning activities is structured by digital literacy through the competencies and abilities needed for internet, ICT, and media literacy (Rizal, Rusdiana, Setiawan, & Siahaan, 2022). Students' digital literacy abilities show a very poor category with a score of 32.81%, which is inversely proportional to students' use of electronic devices such as laptops, cellphones, and tablets, with a score of 97.8% (Pratama, Hartini, & Misbah, 2019). The connection between science and human life has shown rapid progress, thanks to human success in analyzing and describing nature through technology (Kurniawati & Nita, 2018). Physics, which is closely related to human life, is expected to be mastered by students at school by integrating one of the abilities in 21st-century learning, namely digital literacy.

Digital literacy ability is very important in learning physics. Students' competence in digital technology in learning allows students to access, receive, and apply their knowledge (Xiao, 2023). Students' digital literacy abilities (the ability to access, evaluate, and communicate information using appropriate digital tools) are now an integral part of learning (Campanozzi, Gibelli, Bailo, Nittari, Ascanio, & Ricci, 2023). The various tools and technologies used to study physical phenomena and processes do not always obtain positive results when learning takes place (Tereshchuk, Sharov, Tereshchuk, Kolmakova, & Sharova, 2023). Most of the material in physics learning consists of abstract concepts and is difficult for students to understand, so digital literacy ability is needed.

Digital literacy skills in physics learning are expected to enable students to understand abstract physics concepts. The digital literacy level of students in physics learning is still relatively low, with a score of 46.7% in searching for information about physics concepts on the internet (Rahayu, Mayasari, & Huriawati, 2019). Most students consider physics concepts that use a lot of graphic illustrations, symbols, and equations to be very difficult to understand (Setyaningrum & Wiyatmo, 2016). One of the physics materials, namely sound waves, shows that 77.7% of students find it difficult to learn this material (Hasanah, Huda & Kurniawati, 2017). The 2019 National Examination results showed that sound wave material, specifically in determining the amplitude and intensity of sound, had a relatively low achievement with an overall score of 32.13% (Pusat Penilaian Pendidikan, 2019). Conventional learning processes cannot present abstract natural phenomena and symptoms, so students usually find it difficult to understand the material.

The increasingly rapid development of technology means that physics learning must follow these developments. The physics learning process in schools still has several shortcomings, especially in the facilities and infrastructure that can support students' learning activities (Sumiati, Septian, & Faizah, 2018). Apart from that, a problem that often occurs is the availability of learning resources, which are still monotonous by relying on textbooks or worksheets, so students are lazy to study them (Purnawati,

Maison, & Haryanto, 2020). Learning is very beneficial if you use learning media, especially books in electronic form.

Physics books in electronic form are a solution that allows students to learn actively without requiring maximum assistance from educators, enabling them to learn independently. The existence of physics books provides opportunities for students to carry out remedial or correct weaknesses, mistakes, and deficiencies and to find their own evaluations, which are given continuously (Herawati & Muhtadi, 2018). Textbooks that are thick and heavy make it difficult for students, so learning resources are needed that must be packaged in the technology they have (Pramana & Novi, 2014). Currently, students prefer to bring laptops or gadgets rather than textbooks.

Books in electronic form can be a solution nowadays because of the tendency of students to use laptops or gadgets. E-books are a form of presenting learning material that is systematically arranged into certain learning units and presented in electronic format (Suyoso & Nurohman, 2014). In contrast to printed books, e-books offer the advantage of helping students visualize abstract concepts, thereby facilitating a deeper understanding of the material (Osman & Lee, 2013). E-books developed using websites such as Google Sites can be attractive (Mahmuddin, Ratnawati, & Khaharsyah, 2022). Books in electronic form are expected to be effective in learning, including physics subjects.

Physics material in e-books must be linked to students' daily lives so that they are able to understand physics material contextually, which is integrated with local wisdom. Student interaction with the surrounding environment can be done by introducing local wisdom in the area where they live (Wiyono, Ismet, Andriani, Fitonia, Nadia, Meitasari, & Nazhifah, 2024). Local wisdom in physics is an interdisciplinary field of study about perceptions, classifications, and models used by cultural groups to solve everyday problems, especially in the field of physics (Rosa & Orey, 2014). Learning will be more meaningful for students if the material studied is integrated with their lives (Triwiyono & Adiwikarta, 2015). E-books that are linked to local wisdom values can be effective in learning, especially in physics subjects.

One of the local wisdoms of South Sulawesi is traditional musical instruments such as *Puik-puik* (wind instrument) and *Kacaping* (stringed musical instrument). *Kacaping* is played by plucking it to produce sound from a physics concept called strings, while the sound source of *Puik-puik* (one form of organ pipe) comes from the vibration of air in the pipe column that rubs against the air when blown by the player. *Puik-puik* is played together with other traditional musical instruments such as sepapang gandrang, dengkang, and katto-katto (Hudzaifah, 2020). *Kacaping* is played as a single instrument in activities that are purely entertainment (Subhan, 2018). Musical instruments are closely related to the material of sound waves, so it is very important to develop electronic physics books that are integrated with *Kacaping* and *Puik-puik*.

Based on the description above, it is very important for physics books to be developed in electronic form based on *Kacaping* and *Puik-puik* on sound wave material. Researchers designed a research entitled Development of a Physics E-book based on *Kacaping* and *Puik-puik* with the help of Google Sites on Sound Wave Material to improve students' critical thinking abilities and digital literacy.

METHODS

This research is a Research and Development (R&D) study to develop a Physics E-book based on *Kacaping* and *Puik-puik*, utilizing Google Sites to enhance the material on sound waves, with the goal of improving students' Critical Thinking Abilities and Digital Literacy. The development model used is the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) development model for designing and developing learning systems (Smith & Ragan, 1999). The e-book implementation was carried out in three classes, namely experimental class 1, experimental class 2, and control class at SMAN 9 Makassar. The research design used in the field trial was a pretest-posttest control group.

This research employs various data collection techniques and instruments, including observation, interviews, test and non-test instruments, and documentation. The data analysis technique used in this research is as follows.

Product Feasibility Analysis

The assessment process for the physics e-book being developed was carried out based on validation results from experts, physics teachers, and peer reviewers. The e-book quality category is determined based on the results of the analysis carried out in the following steps:

1. Tabulate all data for each assessment component available in the assessment instrument obtained from all validators.
2. Calculate the average value of each component using the Eq.1.

$$\bar{X} = \frac{\Sigma X}{n} \quad (1)$$

with:
$\bar{X}$ = average score
ΣX = the total score for each assessment for a particular component
n = number of appraisers

The quality of the product being developed will be assessed by converting the original data, in the form of quantitative scores, into qualitative (interval) data on a scale of 1 to 4. The conversion of scores into interval data is presented in TABLE 1.

TABLE 1. Determination of intervals on a scale of 1 to 4 (Widoyoko, 2017)

Interval	Score	Category
$3.25 < \bar{X} \leq 4.00$	76% - 100%	Very Feasible
$2.50 < \bar{X} \leq 3.25$	51% - 75%	Feasible
$1.75 < \bar{X} \leq 2.50$	26% - 50%	Not Feasible
$1.00 < \bar{X} \leq 1.75$	0 - 25%	Very Not Feasible

Instrument Validation Analysis

The instruments in this research include both test instruments, in the form of questions, and non-test instruments, in the form of response questionnaires. Validation of the collected data can be done using the following steps:

1. All data obtained from the validator is entered into the table.
2. Calculate validation values using Aiken's V analysis. The score obtained from the validator is calculated using the V Aiken formula using the Eq.2:

$$V = \frac{\Sigma s}{[n(c-1)]} \quad (2)$$

with:
Σs = the sum of the validity scores given by each assessor for each item $(r - l_0)$
r = validator result value
l_0 = lowest validator assessment number
n = number of assessing validators
c = highest validator assessment number

All scores obtained can be categorized into four categories by comparing the V Aiken value between 0 and 1 with the quality category shown in TABLE 2.

TABLE 2. V Aiken quality criteria

Scoring Range	Quality Category
$0.2 < V \leq 0.4$	Not Enough
$0.4 < V \leq 0.6$	Enough
$0.6 < V \leq 0.8$	Good
$0.8 < V \leq 1$	Very Good

Empirical Test Analysis of Critical Thinking Ability and Digital Literacy Test Instruments

Empirical tests were used to analyze items from validated critical thinking ability and digital literacy tests. Item analysis was performed using the Quest program. The purpose of item analysis is to determine the correct and reliable number of test questions for field tests. Reliability results are obtained by examining the item estimation pool and case estimation pool. The instrument's reliability value is assessed by comparing the analysis results with the KR-20 sample in TABLE 3.

TABLE 3. Reliability values

Reliability Score	Interpretation
0.00 – 0.20	Very low reliability
0.21 – 0.40	Low reliability
0.41 – 0.60	Moderate reliability
0.61 – 0.80	High reliability
0.81 – 1.00	Very high reliability

Product Effectiveness Analysis

Product Effectiveness Analysis uses two tests, namely the statistical prerequisite test and the MANOVA test. The testing process steps include (a) identifying the null hypothesis and alternative hypothesis; (b) establishing the level of significance, or alpha level; (c) collecting data; (d) calculating sample statistics; and (e) making a decision to reject or accept the hypothesis (Creswell, 2012). The analysis of product effectiveness is carried out using statistical prerequisite tests (normality test and homogeneity test) and the MANOVA test (hypothesis testing and effectiveness contribution).

RESULTS AND DISCUSSION

Analysis Stage

The analysis was conducted based on the information obtained to utilize the physics E-book on sound wave material, which is expected to enhance students' learning abilities, particularly in critical thinking and digital literacy. The analysis stage carried out includes several analyses:

1. *Learner analysis*

   Student analysis was conducted to identify the characteristics of students in learning activities, ensuring a match between the students' characteristics and the physics E-book product based on *Kacaping* and *Puik-puik*'s sound wave material. The results of the analysis of students who will be research subjects are students in class XI MIPA, with a level of cognitive understanding expected to be in the logical and abstract thinking phase. Apart from that, students' tendency to use technology such as PCs/Laptops and Smartphones shows the suitability between the characteristics and the product to be developed.

2. *Task Analysis*

   A task analysis was conducted by reviewing the Core Competencies (KI) and Basic Competencies (KD) outlined in the 2013 Curriculum. The focus is on KI 3 and KI 4, as well as KD 3.10 and KD 4.10. KI 3 emphasizes understanding, applying, and analyzing factual, conceptual, procedural, and metacognitive knowledge with curiosity toward science, technology, arts, culture, and humanities, while applying procedural knowledge to solve problems according to students' talents and interests. KI 4 emphasizes the processing, reasoning, and presentation of knowledge in both concrete and abstract domains, encouraging independent, effective, and creative learning, and applying methods based on scientific principles.

3. *Concept Analysis*

   Concept analysis was carried out to identify the scope of material about sound waves, which was applied in class XI SMA in the even semester. The material analyzed has been adapted to Permendikbud No. 69 of 2013, concerning the Basic Framework and Curriculum Structure for Senior High Schools/Madrasah Aliyah.

4. Learning Objective Specifications

Learning objectives are specified from task analysis and concept analysis. The learning objectives for the 3 learning activities use a problem-based learning model, which is carried out independently in accordance with the function of the *Kacaping* and *Puik-puik* based physics e-book on sound wave material.

Design Stage

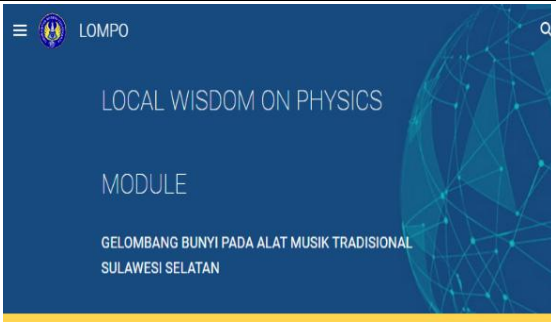
The Physics e-book product, based on *Kacaping* and *Puik-puik*, focuses on sound wave material and is designed to enhance the critical thinking and digital literacy skills of class XI high school students. The guidelines for efforts to improve students' abilities in critical thinking and digital literacy are presented in TABLE 4.

TABLE 4. Analysis of physical aspects of physics e-books on sound wave material

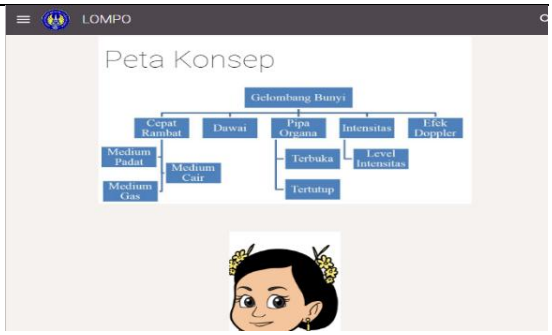
Sub Material	Critical Thinking Indicators	Digital Literacy Indicators
Fast Wave Propagation	Students are able to carry out tests independently regarding the speed of sound wave propagation on a harp musical instrument. (Independence)	Students are expected to be able to develop ways to search for and provide information on internet use. (Information)
String	Students are able to evaluate and consider statements about the frequency of the basic note and the second top note on a string. (Evaluate)	Students are expected to be able to design ways to share information using online tools. (Communication)
Organ Pipe	Students are able to present arguments through explanations about the frequency of notes from an open organ pipe. (Explain)	Students are expected to make conclusions regarding existing knowledge and new knowledge acquired. (Content Creation)
Intensity and Intensity Levels	Students are able to analyze arguments related to the differences in weak and strong sounds when playing the *Puik-puik* musical instrument. (Analyzing)	Students are asked to design methods to protect personal data on computers. (Security)
Doppler Effect	Students are able to interpret the meaning of the sound frequency of a musical instrument with the listener approaching the musical instrument at a certain distance. (Interpret)	Students are expected to be able to design appropriate methods for solving problems using digital devices. (Solve the problem)

The product design stage is carried out by creating a website using Google Sites as a website creation service provider. Examples of product displays for physics e-books based on *Kacaping* and *Puik-puik* on sound wave material can be seen in several examples of product displays in TABLE 5.

TABLE 5. Display of Physics e-book products based on *Kacaping* and *Puik-puik*



Main Page



Concept Maps

Introduction

Material Description

Development Stage

Product Suitability

Product suitability assessment is divided into two, namely media suitability and material suitability. The assessment process involves validators consisting of two expert lecturers, one physics teacher, and two peer reviewers. Data from product assessment results in terms of media suitability based on validation are presented in TABLE 6 and TABLE 7.

TABLE 6. Media feasibility results of physics e-book product

Aspect	Indicators	Average Score	Percentage (%)	Category
Visual Display	1	3.4	85	Very Feasible
	2	3.6	90	Very Feasible
	3	4	100	Very Feasible
	4	3.6	90	Very Feasible
	5	3.8	95	Very Feasible
	6	4	100	Very Feasible
	7	4	100	Very Feasible
Software Engineering	8	4	100	Very Feasible
	9	4	100	Very Feasible
	10	4	100	Very Feasible
Average		3.84	96	Very Feasible

TABLE 7. Material feasibility results from physics e-book product

Aspect	Indicators	Average Score	Percentage (%)	Category
Learning	1	4	100	Very Feasible
	2	3.6	90	Very Feasible
	3	3.6	90	Very Feasible
Material	4	4	100	Very Feasible
	5	4	100	Very Feasible
	6	4	100	Very Feasible
	7	4	100	Very Feasible
	8	3.6	90	Very Feasible
	9	3.6	90	Very Feasible
	10	4	100	Very Feasible
Language	11	4	100	Very Feasible
	12	3.6	90	Very Feasible
	13	4	100	Very Feasible
Average		3.85	96.15	Very Feasible

TABLE 6 and TABLE 7 show that the assessment of the Physics e-book product based on *Kacaping* and *Puik-puik* on sound wave material in terms of material can be categorized as suitable for use in learning. The average media feasibility of the validators reached a score of 3.84; theoretically, the score is in the very feasible category with a percentage value of 96%. The average media feasibility of the validators reached a score of 3.85; theoretically, the score is in the very feasible category with a percentage value of 96.15%.

Instrument Validation

1. Validation of Critical Thinking and Digital Literacy Ability Instruments
   The results of instrument validation were carried out by validators, including expert lecturers, physics teachers, and peer reviews of all critical thinking and digital literacy test items before being tested. The validation results were analyzed using the V Aiken equation obtained in TABLE 8 and TABLE 9.

TABLE 8. Results of Validation of Critical Thinking Test Instrument

Item	Score	Category
1	0.93	Very Good
2	0.93	Very Good
3	1.00	Very Good
4	0.93	Very Good
5	1.00	Very Good
6	0.87	Very Good
7	1.00	Very Good
8	0.87	Very Good
9	1.00	Very Good
10	0.87	Very Good
Average	0.94	Very Good

TABLE 9. Digital Literacy Test Instrument Validation Results

Item	Score	Category
1	0.93	Very Good
2	0.93	Very Good
3	1.00	Very Good
4	0.93	Very Good
5	1.00	Very Good
Average	0.94	Very Good

Based on TABLE 8 and TABLE 9, the average V Aiken values for critical thinking and digital literacy test items are both 0.94, categorized as Very Good.

2. Validation of Student Response Questionnaire
   The validation results of the student response questionnaire were carried out by validators, including expert lecturers, physics teachers, and peer reviewers to see the readability of the *Kacaping* and *Puik-puik* based physics e-books. The validation results of the response questionnaire were analyzed using the V Aiken equation obtained in TABLE 10.

TABEL 10. Student Response Questionnaire Validation Results

Item	Score	Category
1	1	Very Good
2	1	Very Good
3	0.93	Very Good
4	0.93	Very Good
5	1	Very Good
6	1	Very Good
7	1	Very Good
8	1	Very Good
9	1	Very Good
10	1	Very Good
11	1	Very Good
12	1	Very Good
13	0.93	Very Good
14	1	Very Good
15	0.93	Very Good
16	1	Very Good
17	1	Very Good

Item	**Score**	**Category**
18	1	Very Good
19	1	Very Good
20	1	Very Good
Average	0.99	Very Good

Based on TABLE 10, the average result of all student response questionnaire items for the Physics e-book based on *Kacaping* and *Puik-puik* using V Aiken analysis is 0.99, which is in the Very Good category.

Results of limited student trials

1. Empirical Test of Critical Thinking Ability and Digital Literacy Test Instruments
The empirical test in this research was a test of the questions carried out on class XI MIPA students at SMAN 2 Makassar, SMAN 4 Makassar, SMAN 12 Makassar, and SMAN 14 Makassar, totaling 140 students. Reliability testing is conducted by reviewing the results of the summary of item estimates and the summary of case estimates. The test results show that the summary of item estimates and summary of case estimates values for each ability are in the reliable category, as shown in FIGURE 1, FIGURE 2, FIGURE 3, and FIGURE 4.

```
Berpikir Kritis
----------------------------------------------------
Item Estimates (Thresholds)
all on all (N = 140 L = 5 Probability Level= .50)
----------------------------------------------------

Summary of item Estimates
=========================

Mean                          .00
SD                           1.01
SD (adjusted)                 .91
Reliability of estimate       .80


 Fit Statistics
================

 Infit Mean Square         Outfit Mean Square

    Mean      .99             Mean      .96
    SD        .11             SD        .14


      Infit t                   Outfit t

    Mean     -.08             Mean      .27
    SD       1.02             SD        .26
```

FIGURE 1. Summary of item estimates Critical Thinking

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Literasi Digital
----------------------------------------------------
Item Estimates (Thresholds)
all on all (N = 140 L = 5 Probability Level= .50)
----------------------------------------------------

Summary of item Estimates
=========================

Mean                          .00
SD                           1.22
SD (adjusted)                1.11
Reliability of estimate       .83


 Fit Statistics
================

 Infit Mean Square         Outfit Mean Square

    Mean      .96             Mean      .98
    SD        .13             SD        .14


      Infit t                   Outfit t

    Mean     -.35             Mean      .22
    SD       1.15             SD        .33
```

FIGURE 2. Summary of item estimates Digital Literacy

```
Berpikir Kritis
----------------------------------------------------
Case Estimates
all on all (N = 140 L = 5 Probability Level= .50)
----------------------------------------------------

Summary of case Estimates
=========================

Mean                         -.80
SD                           2.38
SD (adjusted)                2.02
Reliability of estimate       .72


 Fit Statistics
================

 Infit Mean Square         Outfit Mean Square

    Mean      .95             Mean      .95
    SD        .85             SD        .84


      Infit t                   Outfit t

    Mean     -.09             Mean      .13
    SD       1.28             SD       1.57
```

FIGURE 3. Summary of case estimates Critical Thinking

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Literasi Digital
----------------------------------------------------
Case Estimates
all on all (N = 140 L = 5 Probability Level= .50)
----------------------------------------------------

Summary of case Estimates
=========================

Mean                         -.51
SD                           2.19
SD (adjusted)                1.96
Reliability of estimate       .80


 Fit Statistics
================

 Infit Mean Square         Outfit Mean Square

    Mean      .96             Mean      .99
    SD        .80             SD        .89


      Infit t                   Outfit t

    Mean     -.04             Mean      .19
    SD       1.16             SD       1.43
```

FIGURE 4. Summary of case estimates Digital Literacy

FIGURE 1 and FIGURE 3 show the results of the summary of item estimates from measuring critical thinking ability and digital literacy are 0.80 and 0.83. FIGURE 2 and FIGURE 4, the summary of case estimates from measuring critical thinking ability and digital literacy are 0.72 and 0.80. Both values are in the reliable category. So the questions are good to use as a research test instrument to measure critical thinking ability and digital literacy.

2. Small Scale Test

Small-scale tests or initial field trials were carried out involving class XI MIPA students at SMAN 14 Makassar. The assessment is carried out by students using a response questionnaire regarding the use of Physics e-book media based on *Kacaping* and *Puik-puik* on sound wave material which has been validated by expert lecturers. The number of students in this initial field trial was 34 students with various academic abilities. The results of the physics e-book assessment can be presented in FIGURE 5.

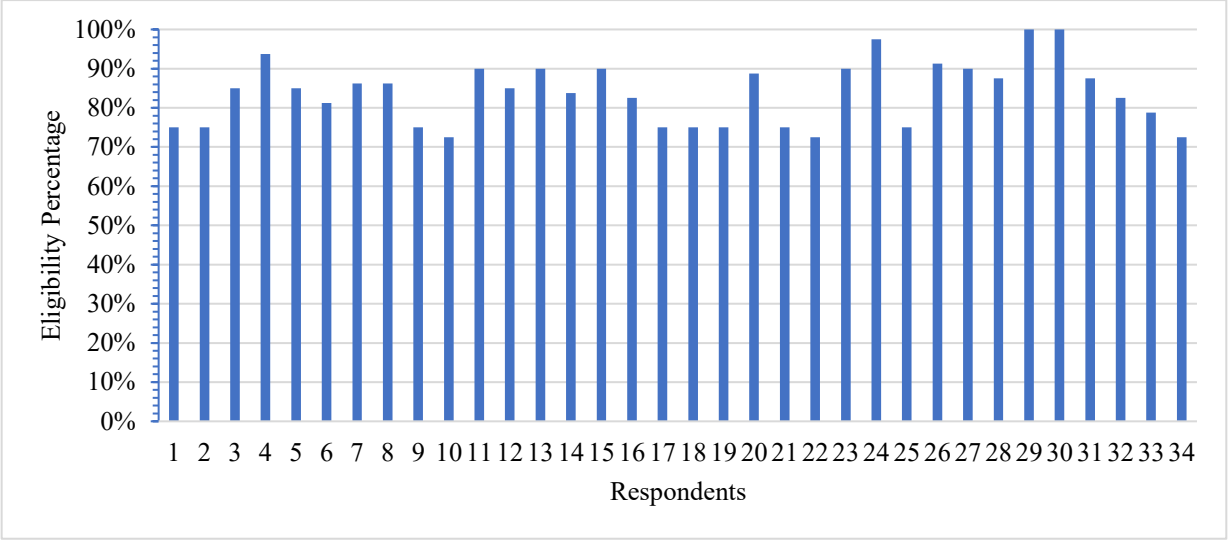

FIGURE 5. Results of e-book feasibility assessment in small-scale trials

FIGURE 5 displays the results of e-book feasibility in a small scale test with a total of 34 students responding with an average feasibility percentage of 84%. Based on the results of the feasibility of the e-book in a small scale test, it can be concluded that the product is suitable for use in learning sound wave material. Therefore, the product can be continued at the implementation stage.

Implementation Stage

Normality Test

The normality test is one of the important requirements that must be met before carrying out the MANOVA test. Test results on the normality test using Shapiro-Wilk. The results of the normality test can be seen in TABLE 11.

TABLE 111. Results of Normality Test

Class		***Shapiro-Wilk*** **Statistic**	**Df**	**Sig.**
Pretest of Critical Thinking	Experiment 1	.935	30	.066
	Experiment 2	.980	30	.836
	Control	.935	26	.101
Posttest of Critical Thinking	Experiment 1	.943	30	.107
	Experiment 2	.980	30	.834
	Control	.989	26	.992
Pretest of Digital Literacy	Experiment 1	.940	30	.091
	Experiment 2	.976	30	.726
	Control	.973	26	.708
Posttest of Digital Literacy	Experiment 1	.932	30	.054
	Experiment 2	.978	30	.780
	Control	.970	26	.634

TABLE 11 shows the sig value obtained. more than 0.05 for the pretest and posttest critical thinking ability scores for experimental class 1, experimental class 2, and control class. So it can be stated that H0 is accepted, because it is in accordance with statistical theory, namely that data can be categorized as normal if the sig. greater than 0.05. This also proves that the three-class data are normally distributed.

Homogeneity Test

The homogeneity test aims to see that the samples come from the same or homogeneous population. The homogeneity test can be seen from the pretest-post test scores for critical thinking ability and digital literacy in the three testing classes. The results of data analysis in the homogeneity test can be seen in the Test of Homogeneity of Variance or Levene's Test of Equality of Error Variance based on the Median value. The results of the homogeneity test can be displayed in TABLE 12.

TABLE 12. Results of Homogeneity Test

Test Type	Levene Statistic	df1	df2	Sig.
Pretest of Critical Thinking	1.563	2	83	.216
Posttest of Critical Thinking	1.057	2	83	.352
Pretest of Digital Literacy	2.980	2	83	.056
Posttest of Digital Literacy	1.501	2	83	.229

Based on the homogeneity test in TABLE 12, the pretest-posttest value for each ability obtained is greater than the sig level. namely 0.05, then H0 is accepted. The results of the homogeneity test concluded that the samples could be divided into homogeneous or come from the same variant.

The MANOVA test

The MANOVA test was carried out to determine the differences in learning outcomes before and after treatment using different learning tools for each research class. The MANOVA test was carried out using SPSS 24 with a significant level of 5% or 0.05. If the significance value is less than 0.05 then H0 is rejected, meaning there are differences in learning outcomes between the third classes. Brief MANOVA test results can be seen in TABLE 13.

TABLE 13. Result of The MANOVA Test

Effect	Sig.	Conclusion
Hotteling's Trace	0.005	H_0 rejected

TABLE 13 shows the Hotteling's Trace statistical results with a significance value of 0.005. If the significance value shows less than 5% or 0.05 then there is a significant difference between the independent variable and all dependent variables. The results of data analysis obtained with a significance value of 0.005 < 0.05, then H0 is rejected. So, in conclusion, there are differences in the critical thinking abilities and digital literacy of students who use physics e-books, printed books and textbooks provided by the teacher during learning.

Average Results of Critical Thinking Ability

The results of students' critical thinking abilities can be seen from the pretest and posttest assessments that have been tested to students. The students consisted of three classes, namely Experiment 1, Experiment 2, and Control, with different treatments. The average critical thinking ability was determined using descriptive statistics in SPSS. TABLE 14 displays the pretest and posttest results of students in each class.

TABLE 14. Results of critical thinking ability

Class	Number of Students	Average Ability	
		Pretest	Posttest
Experiment 1	30	32.53	56.5
Experiment 2	30	35.87	43.6
Control	26	38.47	42.89
Average		35.47	47.89

TABLE 14 shows that the differences in the pretest and posttest averages are visible due to the different treatment of the use of learning resources carried out in each class. Experimental class 1 used e-books, experimental class 2 used printed books and the control class used teacher package books.

Average Digital Literacy Ability Results

The results of students' digital literacy ability can be seen from the pretest and posttest assessments that have been tested on students. The students consisted of three classes, namely Experiment 1, Experiment 2, and Control with different treatments. Average digital literacy ability were obtained through Descriptive Statistics in SPSS. TABLE 15 displays the pretest and posttest results of students in each class.

TABLE 15. Results of digital literacy ability

Class	Number of Students	Average Ability	
		Pretest	Posttest
Experiment 1	30	41.17	62.67
Experiment 2	30	41.23	44.47
Control	26	41.47	48.12
Average		41.28	51.92

TABLE 15 shows that the differences in the pretest and posttest averages are visible due to the different treatment of the use of learning resources carried out in each class. Experimental class 1 uses e-books, experimental class 2 uses printed books and the control class uses a textbook from the teacher.

Hypothesis 1 Results

Hypothesis 1 shows an interaction on students' critical thinking ability and digital literacy. The interaction of students' critical thinking ability and digital literacy can be analyzed using SPSS output in the subject counter table. TABLE 16 shows the results of the within-subject contrasts with the ability interaction assessment seen in the time* class section.

TABLE 16. Test of Within-Subject Contras

Source	Measure	Time	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Time	MEASURE_1	Level 1 vs Level 2	12412.242	1	12412.242	47.495	<.001	.364
	MEASURE_2	Level 1 vs Level 2	9370.987	1	9370.987	31.678	<.001	.276
time* class	MEASURE_1	Level 1 vs Level 2	6321.379	2	3160.689	12.094	<.001	.226
	MEASURE_2	Level 1 vs Level 2	5597.074	2	2798.537	9.490	<.001	.186
Error (time)	MEASURE_1	Level 1 vs Level 2	21691.176	83	261.340			
	MEASURE_2	Level 1 vs Level 2	24552.751	83	295.816			

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to not adjustments).

The significance value of the time*class section shows a result of 0.001 < 0.05, so there is a significantly different interaction between the pretest and posttest for critical thinking ability and digital literacy in each class.

Hypothesis 2 Result

Hypothesis 2 shows that there are differences in students critical thinking and digital literacy. The results of increasing critical thinking and digital literacy through the use of physics e-book are displayed in Pairwise Comparison table in the IBM SPSS output.

TABLE 17. Pairwise comparison

Measure	Class	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig. [b]	95% Confidence Interval for Difference [b]	
							Lower Bound	Upper Bound
MEASURE_1	Experiment 1	1	2	-23.967*	2.951	<.001	-29.837	-18.096
		2	1	23.967*	2.951	<.001	18.096	29.837
	Experiment 2	1	2	-7.733*	2.951	.010	-13.604	-1.863
		2	1	7.733*	2.951	.010	1.863	13.604
	Control	1	2	-4.423	3.170	.167	-10.729	1.883
		2	1	4.423	3.170	.167	-1.883	10.729
MEASURE_2	Experiment 1	1	2	-21.500*	3.140	<.001	-27.746	-15.254
		2	1	21.500*	3.140	<.001	15.254	27.749
	Experiment 2	1	2	-3.233	3.140	.306	-9.472	3.012
		2	1	3.233	3.140	.306	-3.012	9.479
	Control	1	2	-6.654	3.373	.052	-13.363	.055
		2	1	6.654	3.373	.052	-.055	13.363

The significance values of the critical thinking and digital literacy variables show different results. The critical thinking ability of experimental class 1 and experimental 2 showed an increase from pretest to posttest scores with a sig value. < 0.05, while the control class did not show an increase because it obtained a sig value. 0.167. The digital literacy ability of experimental class 1 and control class showed an increase from pretest to posttest scores with a sig value. < 0.05, while experimental class 2 did not show an increase because they obtained each successive sig value. 0.306.

Effectiveness Contribution

The contribution of effectiveness analysis is data that displays the influence between the use of products developed and the learning tools used in schools. Test the effectiveness of the independent variable, which consists of three class categories, namely experimental class 1 (physics e-book based on *Kacaping* and *Puik-puik* on sound wave material), experimental class 2 (printed physics book), and control class (package book from school), while the engagement variables that want to be improved are critical thinking ability and digital literacy. The effectiveness test analysis was obtained by multivariate analysis using the General Linear Model (GLM) in the hoteling's trace multivariate test. The effectiveness test results for experimental class 1, experimental class 2, and control class in increasing critical thinking ability and digital literacy were respectively obtained at 55%, 8%, and 6%. Analysis of effectiveness in the experimental and control classes was carried out using post-hoc further tests, which produced graphs in SPSS. Increased critical thinking ability and digital literacy can be seen in the Estimation of Marginal Means section in FIGURE 6 and FIGURE 7.

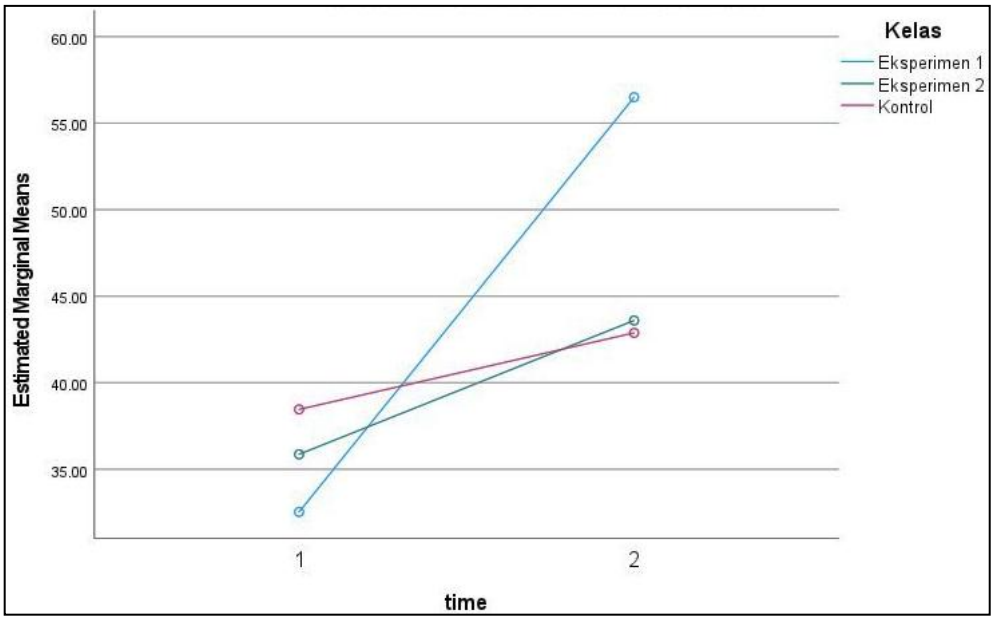

FIGURE 6. Graph of increasing critical thinking ability

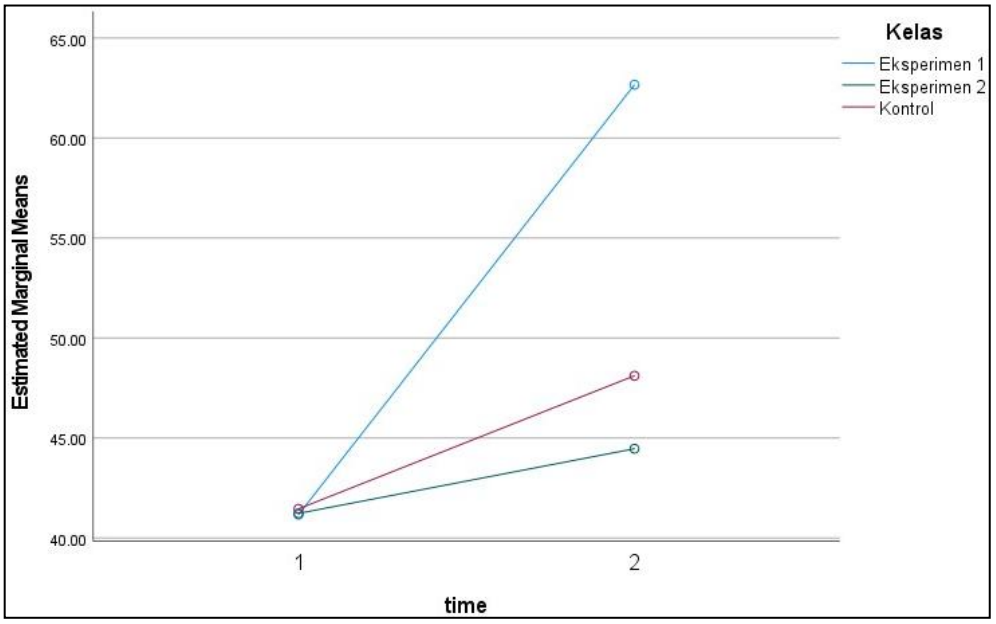

FIGURE 7. Graph of increasing digital literacy ability

FIGURE 6 and FIGURE 7 show that the increase in critical thinking ability and digital literacy in experimental class 1 is higher when compared to the other 2 classes. As for the visible interaction between critical thinking ability and digital literacy, there are different lines on the graph between the experimental class and the control class in each class.

Evaluation Stage

The evaluation stage in this research was carried out by analyzing the results of empirical tests on students and product modifications that were developed after implementation on students. The evaluation was carried out to determine the effect of using physics e-book products on sound wave material and to explore students' critical thinking and digital literacy ability after receiving different

treatments for each student. Evaluation is given to make the final product of a physics e-book good for use in physics learning.

CONCLUSION

Based on the research results from the Physics E-book based on *Kacaping* and *Puik-puik*, the following conclusions were obtained.

1. Physics e-books based on *Kacaping* and *Puik-puik* material on sound waves are suitable for improving students' critical thinking abilities and digital literacy, as validated by expert results, which take into account both material and media aspects. Based on data, the results indicate that the product is in a category that is very suitable for use.
2. Physics e-books based on *Kacaping* and *Puik-puik* on sound wave material to improve students' critical thinking ability and digital literacy are relevant for use based on readability or the results of limited trials consisting of two, namely empirical tests and small-scale tests. In the empirical test of the critical thinking ability test, the item of estimates was reliable category and the case of estimates was a reliable category, while in the empirical test of the digital literacy ability test, the item of estimates was a reliable category and the case of estimates was reliable category. In the small-scale test, an average score was obtained; this score was categorized as relevant.
3. Physics e-books based on *Kacaping* and *Puik-puik* material on sound waves are effective in improving students' critical thinking abilities and digital literacy, as demonstrated by the results of product implementation in experimental classes 1, 2, and the control class. The implementation results of the three classes where experimental class 1 used the product developed with higher results than experimental class 2, and the control class which did not use the *Kacaping*-based Physics E-book product and *Puik-puik*.

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