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Development of Google Sites Based E-books on Sound Wave Material with STEM-PBL Model to Improve Mathematical Literacy and Critical Thinking Skills

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ABSTRACT
This research aims to: 1) Produce a Google Sites-based e-book using STEM-PBL model on sound wave material based on improving students' mathematical literacy and critical thinking; 2) Understand the practicality of Google Sites-based e-books using STEM-PBL model to sound wave material based on increasing students' mathematical literacy and critical thinking; 3) To find out the effectiveness of Google Sites-based e-books using STEM-PBL model to sound wave material based on increasing students' literacy and critical thinking. This research used ADDIE development model and was conducted at SMA Negeri 5 Yogyakarta. The number of subjects in this research was 250 students for the empirical test, 36 students for the limited trial, and 108 students for the extensive trial. The research instrument consists of product assessment sheet, practicality questionnaire, mathematical literacy and critical thinking test. The results show that: 1) e-book media based on google sites with STEM-PBL model developed worthy to be used in high school physics learning in particular sound wave material with good category by expert validator; 2) e-Book media with Google sites based on STEM-PBL model developed practically used in learning with the practical category; 3) e-books media with google sites based on STEM-PBL model was effective to enhance mathematical literacy and critical thinking abilities.

INTRODUCTION

Education is an investment for a nation with good education that can create superior that can create superior human resources. Education is also part of human life, in which every human being born will receive education from his parents. Therefore, education must be carried out as best as possible with the aim of producing quality education and can improve the quality of human [1]. Education in the era

of the industrial revolution 4.0 is a representation of the integration of technology into learning activities. Optimization of internet technology and learning activities have brought education into the era of education digitalization [2]. The simplicity of digital education is we can use electronic media in the learning process. Is doesn't have to be expensive, it's enough to fit your needs. For example, if a teacher needs information about his pupils, they can get it with digital data [3].

Indirectly, digital trends in education make learning a process that can be done anywhere and provide facilities for students to obtain extensive information. Usually educators use platforms such as moodle, blogs, to social media as educational media [3]. So form that, learning media innovation is much done by researchers is much done by researchers end the era of digitalization of education by means of the development of digital learning media. One of the learning media for learners who apply the advances of technology and communication with interaction is a digital book or commonly called an e-book [4]. Digital books also known as e-books are publications consisting of text, images or audio, published in digital format and readable by a computer or digital device. Other electronic devices such as hand phones or tablets [5].

Google sites is one of the digital learning media innovations. Google sites are Google features that provide web browsing functionality. Visit pages are managed in the form of web page screens containing text and instructional videos. Results of research conducted by previous researchers on improved conceptual mastery and critical thinking about the use of google sites show that there is an improvement in the mastery of conceptual and critically thinking skills of high school pupils, which is appropriate, effective, as well as efficient so that it can be applied in learning [6] [7] [8] [9] [10]. The importance of mathematical literacy as part of the skills of the 21st century is not in line with the ability to literate mathematics in Indonesia [11] [12]. According to the results of the survey of the Programme for International Student Assessment (PISA), the mathematical skills of students are still weak Indonesia is below the international average [13].

Table 1. TIMSS Results Indonesia

Year	Ranking	Number of Participating	Countries Indonesia	Score Average International Score
1999	34	403	403	487
2003	35	411	411	467
2007	36	397	397	500
2011	38	386	386	500
2015	44	397	397	500

Table 2. Average Critical Thinking

No.	Indicator	Percentage (%)
1.	Interpretation	30.25 %
2.	Analysis	36.5 %
3.	Conclusion	23.25 %
4.	Evaluation	45.5%
5.	Explanation	26.75%
6.	Self-regulation	48.5%
Average overall score		**35.124%**

When students' mathematical literacy is low then their ability to think critically is also low [14]. The fact is that Indonesian students' skills are still below international standard. Similar research was also conducted by previous researchers which stated that students' critical thinking skills were still even lower in physics learning, due to the limited ability of students in formulating and finding alternatives to any problem, difficulty drawing conclusions, linking substances between materials [15] [16] [17] [18] [19]. For that, there is a need for models and innovations in the learning system. One of the most popular methods is the methods of Science, Technology, Engineering, and Mathematics (STEM).

Research carried out by previous researchers states that mathematical literacy can be formed using the STEM approach, because in learning with the STEM approach students can apply their knowledge to solve problems [20] [21]. Students are able to criticize plans that have been systematically formulated and provide criticism that builds on the real problems faced [22] [23]. However, contrary to studies that have been conducted by previous researchers [24] [25] [26] that STEM has not been applied to the maximum in schools.

Problem Based Learning (PBL) is a problem-based learning model that is perfectly appropriate if applied to see how critical thinking and mathematical skills of students. Because in learning PBL requires students to access a variety of sources of information, other than from teachers or textbooks, can solve complex real-life problems [27]. For this reason, Caparo in Febril et al [27] stated that "Problem-based learning model is one of the right models for STEM approaches". STEM can improve the thinking of higher pupils, while the PBL model can increase student involvement in the learning process leading to increased motivation and enhanced critical thinking ability. The use of an integrated STEM PBL model can enhance critical thinking skills because of several things: 1) providing simple explanation, 2) building basic skills, 3) concluding, 4) providing further explanations, 5) setting strategies and tactics.

Based on this, there is a need for the development of practical learning patterns that can improve the mathematical literacy and critical thinking of students. 1) How is the feasibility of e-books based on google sites using the STEMPBL approach to sound wave material based on increased mathematical literacy and critical thinking of students? 2) How are the practicalities of google-based e-book sites using STIMPBL's approach to audio wave materials based on improved mathematic literacy of students and critically thinking of them? 3) How efficient is the e-Book based on Google sites using a STEMpBL approach on soundwave material and based on the increase in student mathematics literacy, critical thought?

METHOD

Development Model

The educational material is an e-book that will be developed using the ADDIE model which consists of five stages namely:

1. Analysis

In this phase, the main activity is to analyze the need for the development of teaching materials in the purpose of learning, some analysis is carried out as follows:

a. Performance analysis: at this stage, starting to emerge basic problems encountered in learning. researchers conducted needs analysis through observations at the learning process of sound wave subjects and interviews physics teacher XI grade at high school 5 Yogyakarta State.
b. Student analysis: at this stage is an expression of the characteristics of the student based on his knowledge, skills and development.
c. The analysis of the facts, concepts, principles, and procedures of the material in relation to the fact, the concept, the principle and the procedure is an identification to the material to be relevant to the teaching material in learning.
d. Analysis of learning objectives: is a necessary step to determine the ability or competence that a student needs to have.

2. Design

The design phase includes several planning of the development of the teaching material including several activities as follows: (1) preparation of teaching materials, (2) design of learning scenarios, (3) selection of competencies of the lessons, (4) initial planning of devices based on the competences of the subjects, (5) designing of learning materials and evaluation of artisanal materials.

3. Development

The development phase aims to produce and validate the learning devices that have already been created. In carrying out the development of teaching materials, there are two important objectives that need to be achieved among others are: (1) produce or revise the teaching material that will be used to the purpose of learning that has been formulated, (2) select the best teaching equipment that would be used for achieving the aim of learning.

4. Implementation

At this stage, after the product is validated, the validators implement the product in small groups and then in large groups.

5. Evaluation

Evaluation is one of the stages to see whether the learning system being built works, in line with the expectations of the initial development or not.

Product Trial Design

The product test design is carried out to gather data used as a basis in determining the product of the material being represented. Test design includes: (1) test design, (2) test subject, (3) data collection techniques and instruments, (4) data analysis techniques.

1. Test Design

Product testing is intended to test the validity of the material developed based on material aspects, media aspects of language aspects and user assessment.

Table 3. Research Design

Group	Pretest	Treatment	Post test
$\mathbf{R_1}$	$\mathbf{Q_1}$	$\mathbf{X_1Y_1Y_2}$	$\mathbf{Q_2}$
$\mathbf{R_2}$	$\mathbf{Q_1}$	$\mathbf{X_2Y_1Y_2}$	$\mathbf{Q_2}$
$\mathbf{R_3}$	$\mathbf{Q_1}$	$\mathbf{X_3Y_1Y_2}$	$\mathbf{Q_2}$

Description:

R_1: Experimental group I
R_2: experimental group II
R_3: Control group
Q_1: Pretest
Q_2: Posttest
X_1: Learning treatment using e-book based google sites with STEM-PBL approach
X_2: Learning treat using STEM model
X_3: Conventional model (with PBL model)
Y_1: Mathematical literacy racket
Y_2: Critical thinking racket

2. Test Subject

Subjects in this study tested trial at the level of high school equal in this research the researchers took place in the State High School 5 Yogyakarta class XI. Samples of this research are classes XI IPA 3, XI IPA 4, XI IPA 5, three subsequently selected classes are selected again randomly to determine experiment class 1, experiment class 2, and control class.

3. Data collection Techniques

Development data collection techniques that are structured in this study are:

a. Interview

Process was conducted with the teacher of class XI of the Physics subjects of State High School 5 Yogyakarta. The interview was carried out to obtain data that is present in the classroom in a real way about the activities that are in class as well as any needs that are needed in class.

b. Observation
The observation was conducted at Yogyakarta State High School 5, and the observation process was carried out.

c. Documentation
Documentation The documentation process is aimed at meeting the data required in the development of teaching materials.

d. Questionnaire
Questionnaire is used to determine the practicality and validity of the material developed.

e. Pretest and Posttest
Pretest and posttest will be done at the beginning and end of learning and also in each class, both experiment class 1, experiment class 2, and control class.

RESULTS AND DISCUSSIONS

Results
The results of product development include e-books based on Google sites with a STEM-PBL approach, critical thinking question instruments and question instruments mathematical literacy abilities. This chapter is written coherently according to technique data analysis and stages of research development procedures used, namely with the ADDIE model (Analyze, Design, Develop, Implement, Evaluate).

1. Development Results Initial Product
Development results product among them consists of from *e-book* based on *google sites* with STEM-PBL model, question instrument think critical and instrument questions ability literacy mathematically. In chapter This written with coherent in accordance with technique data analysis and stages procedure development the research used, namely with the ADDIE (*Analyze, Design, Develop, Implement, Evaluate*) model.

a. Analyze Stage (Analysis)
1) Analysis Results Need
Analysis results need This obtained from results mapping and urgency study development, thing This covers activity teacher learning in schools, problems learning during this, and need participant educate in Study physics at SMAN 5 Yogyakarta, school the Still apply 2013 Curriculum for class XI and class XII. At the time learning physics in school said, the material physics explained in accordance coherent book physics from Ministry of Education and Culture 2013 curriculum, as well as material addition originate from LKS physics. Considering source learning used moment this, for sure own advantages and disadvantages. One of them is source learning used No teach content STEM-PBL integrated physics, and learning Still centered to teachers with learning models Not yet varies.

During the interview conducted with physics teachers at SMAN 5 Yogyakarta, resource persons to argue that learning physics is done Not yet Once using the STEM-PBL model and in combination with Google Sites learning media, teachers only need to Once get information related to PBL only and not yet understand How apply it if in combination with STEM. Not only That just problem new appear Again because Not yet There is source relevant learning when will using the STEM-PBL learning model in class especially material physics. Source interesting learning can increase motivation and results Study participant educate become more well, what else when source Study combined match with innovative and efficient learning models.

Researcher return to study repeat matter This in a way comprehensive, when do observation inside

know it turns out participant educate allowed use *smartphone* during the learning process and participants students also get facility *Wifi*, and projector by the school. For utilise matter the researcher interested For use *e-book* based on *google sites* that can accessed from each participant's smartphone educate in learning physics. This is can control use *smartphone* during the learning process.

2) Analysis Results Learners

Analysis results participant educate obtained characteristics possessed by participants educate. Characteristics covering age, level development cognitive, and abilities participant Educate. Analysis This find that improvement results Study Already Good matter This based on the level activity participant educate during the learning process taking place. However, in matter abilities, interests and motivation Still classified as medium and low on learning physics. Just a few participant learners who can answer questions and work task with right, some of it Again No focus moment learn and even cause commotion in class. besides that, the problem was found in analysis need previously cause descent interest, motivation, and participation participant educate. This is Of course impact on quality learning and results Study physics.

Based on the above problems, in the era of education moment this, very important participant educate own ability think critical and literacy mathematically. Because when somebody Already own two ability said, there is Lots benefits that can be obtained obtained like breakdown good problem, ability analysis and evaluation, improvement independence learning, creativity and innovation and still Lots again. Therefore that, researcher must see results Study participant educate, especially in matter think critical and literacy mathematically. The result show that participant educate own ability think critical and literacy low mathematical. Findings This proven when researcher do observation inside class, when the teacher gives exercise question to participant Didik It looks like some participant educate difficulty in answer question Not only that. that, researchers also saw results test daily, test mid- term and exams end of semester on material previously found low yields. Difficulties experienced participant educate This will impact on ability they For connect and apply draft physics is taught. Therefore that, researcher interested developing e-books based on Google Sites with the STEM-PBL model for increase think critical and literacy mathematical participant educate.

3) Analysis Results Draft

Analysis results draft physics obtained characteristics materials and concepts chosen For developed. Analysis This done with studies literature and reading a number of article from journal indexed by Sinta and scopus, journal national and international. In terms of This materials used in research This that is material wave sound, because in the material the participant educate Still Lots experience misconception, because in the material wave sound Lots equality mathematically, and still difficult understand formulas in wave sound like level intensity voice, relationship between intensity sound, relationship between distance and quantity source sound. In addition material wave sound is A abstract material Because No Can seen directly by, so that difficult for participant educate For visualize How wave sound move and interact with medium [28] [29] [30] [31] [32]. Consequence misunderstanding the can create obstacle in understanding concept, interpretation phenomenon everyday, difficulties in breakdown problems, and extensions cycle misconception [33] [34] [35] [36] [37] [38].

Generally participant educate difficulty in understand characteristic wave sound, propagation sound misconception This that sound can creeping in room vacuum, speed and frequency sound, amplitude and intensity difficulty in distinguishing amplitude, intensity and volume of sound, reflection and absorption, difficulties understand interference and resonance, and the doppler effect. Misconceptions This no only for students just but found in prospective physics teachers [33] [39] [40] [41]. For That need the existence of appropriate teaching strategies explicit overcome misconceptions and help participant educate develop better understanding accurate about wave the sound of one of them with use appropriate analogies and models. Teaching using the right model can practice use an accurate and relatable analogy avoid misconception [35] [41].

Physics material presented in study This Still referring to the purpose learning covered in curriculum 2013. Through activity experiment, material physics This can increase ability think critical and

literacy mathematics supported by the STEM-PBL model. Therefore that, tool proper experiment required For support activity learning that discusses analysis technology in matter This.

4) Analysis Results Technology

Analysis results technology produce the right method For applied to the material wave sound. Researcher use activity experiment For to design learning wave sound. Most activity experiment need amount adequate tools and materials.. However, SMAN 5 Yogyakarta still No own adequate facilities For support related experiments with material wave sound. Interview and survey results show that participant educate own access *full smartphone* while at school. Therefore that, for maximize matter the used deep web site learning in the form of *google sites* that provide materials and access For experiments,such as *virtual laboratory physics at school*.

5) Results of Formulating Objectives

Teaching media is developed naturally with objective For to solve problems in the field, and for fulfil need learning. The purpose of development of learning media interactive based on *google sites* in the eyes lesson physics is For make participant less educated enthusiastic become more Spirit because of this media push participant educate For become independent. In addition, with using learning media interactive based on google sites, participants educate can choose the sub material they want want For studied without only listening to the teacher in class. development of learning media interactive web based also has objective For make participant less educated Spirit become more enthusiastic. The development of teaching media also has the aim is for the facilities available at the school can used as teaching media support.

Completion stage analysis This marked with the collection a number of information related participant education and learning process in the classroom. information collected become base For to design solution effective and interactive learning.

b. Design Stage (Designing)

After collecting comprehensive data at the stage analysis, researcher will switch to stage design. Transition to stage design to mark shift from collection information to utilization information the For to form framework effective learning. This is done through several processes, such as:

1) Data collection

Data collection was carried out after analyze standard competence, competence basis and indicators as well as other teaching materials. Material data can see the attachment. After the material data collected, steps next is make *flow chart* or flow chart.

2) Make Design

After data collection is complete, the next step is next is make design for learning media interactive based on *google sites* that will used. In making design There is a number of elements that must be entered to in learning media so that it is structured with systematic, achieving objective learning, and organized with Good.

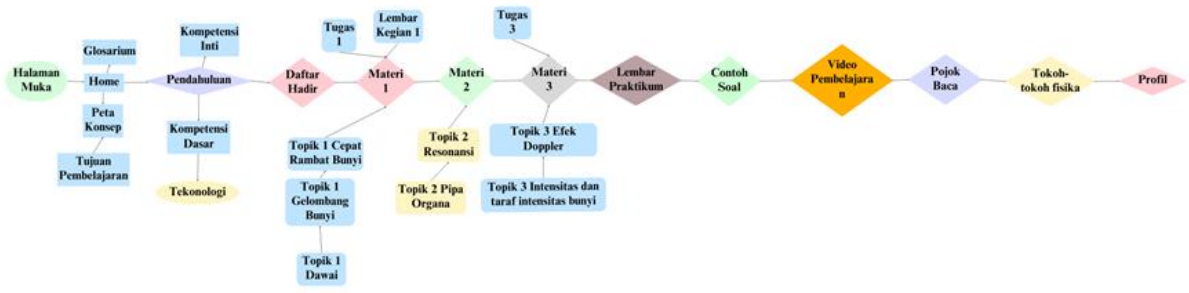


Fig 1. *Flowchart of Teaching Media Planning*

3) E-book Outline Preparation

Compiling an e-book outline based on Google Sites with the STEM-PBL model on the material wave sound designed in the form of the website being operated online. The front page of this e-book consists of from the word motivation, university logos, and connected icons in each sub chapter. Learning objectives, attendance list, materials, examples questions, learning videos, corner read, character physics, and profile are the icons found on the website. When one of these icons is clicked so will direct going to to the intended page. The display of e-books based on Google sites can seen in a way clearly in Figure 2 and Figure 3.

Fig 2. *Google Sites Based E -book Display*

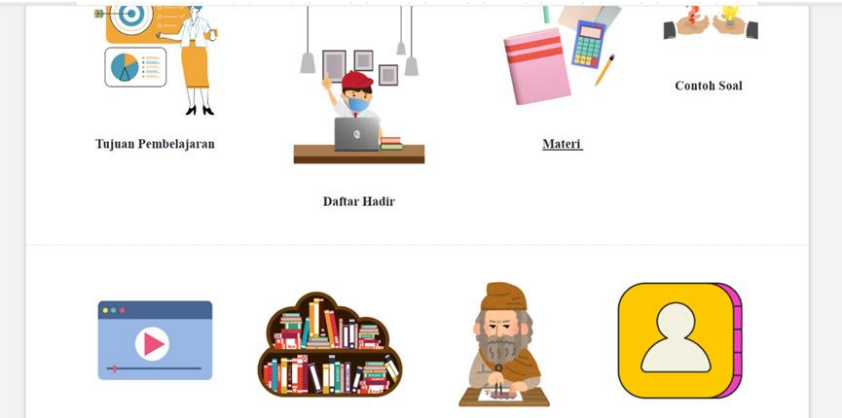


Fig 3. *Icons on the Home Page*

4) Designing E-book Learning Content

Learning content in the e-book includes presentation the material created based on The syntax of the STEM-PBL learning model is: 1) orientation problem, in learning using this e-book participant educate requested make with give description problems in life every day that often encountered by participants educate; 2) organize For learn, in learning using this e-book his activities is ask answer questions that have been asked presented in an e-book based on Google sites, and discussions short about frequently encountered phenomena participant educate Good in a way group and also individual; 3) guiding For investigation in a way in groups in learning; 4) developing and presenting results experiment, in e-book syntax This aiming For do presentation in front class related results the card that has been done; 5) analyze and evaluate breakdown problem, where participant educate requested For give opinion on results learning on the day This.

c. Development Stage (Development)

At the stage This developed e-book based on google sites on the material wave sound with the STEM-PBL model, sheets validation, test instrument literacy mathematics and thinking critical, sheet practicality for teachers and participants educate. But this e-book Not yet become product end Because must through, stage validation, empirical testing, and limited testing. These tests done For know Is the e-book valid and can used through the validator. In the empirical test held with distribute e-books to participant students who have get material at the level previously.

d. Implementation stage

At the stage This conducted a trial in scale big or implementation products that have been developed namely e-books in activity learning physics at SMAN 5 Yogyakarta. At the stage this will also applied to three class, each is formed as two experimental classes and one control. Experimental class First will use products that have been developed class experiment second will use products and learning models others, and classes control will use ordinary teaching materials used by teachers. Implementation This aiming For evaluate how much effective e-book based on google sites that uses the STEM-PBL model for increase ability think critical and literacy mathematical participant educate Good before and also after using the e-book. The purpose of analysis This is For to know how much effective this model in increase ability think critical and literacy mathematical participant educate.

e. Evaluate Stage

Evaluate stage loading revision product in the ADDIE development model. At this stage This divided become two evaluation that is evaluation formative and summative.

1) Evaluation formative

Evaluation formative implemented before test field. Evaluation results formative based on results eligibility products made by lecturers mentors, validators, practitioners, and participants educate. Instruments used in evaluation formative that is questionnaire.

2) Evaluation Summative

Evaluation summative implemented on e-books based on Google sites on the material wave sound with the STEM-PBL model that has been conducted a trial field. Evaluation results summative taken from results test ability literacy mathematical and thinking critical namely on the pretest and posttest values. The data obtained from evaluation summative analyzed and tested.

When evaluating formative and summative has done in a way comprehensive, stage evaluation finished. The result of evaluation This has evaluated in a way comprehensive For measure how much Good objective instructional has achieved and where necessary There is improvement.

2. Revision Product

Stages revision Google sites based e-book products pass through stages validation lecturer experts, physics teachers, and assessments during the trial limited. The results of the research on validation This suggestions and improvements obtained from the validator. Revision results product can seen in the picture.

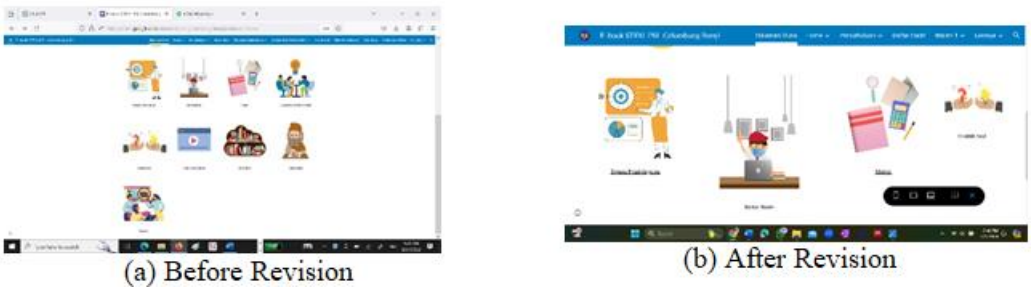


Fig 4. *Revision Initial Menu View*

On the initial menu display there are several icons that can be clicked to go to the next page. However, before the revision there were several errors when accessing the link. For example, on the learning objectives menu when clicked it does not connect to the menu that should be clicked. Furthermore, on the Google sites menu there is no core competency.

Fig 5. *Display Home Menu Revision*

Next, on the home menu, suggestions are given to add STEM-PBL learning indicators, thinking indicators and mathematical literacy indicators. Previously, the home menu only contained concept maps and learning objectives. The purpose of adding this indicator is to make it easier for readers to understand that this Google site uses the STEM-PBL model by increasing 2 variables.

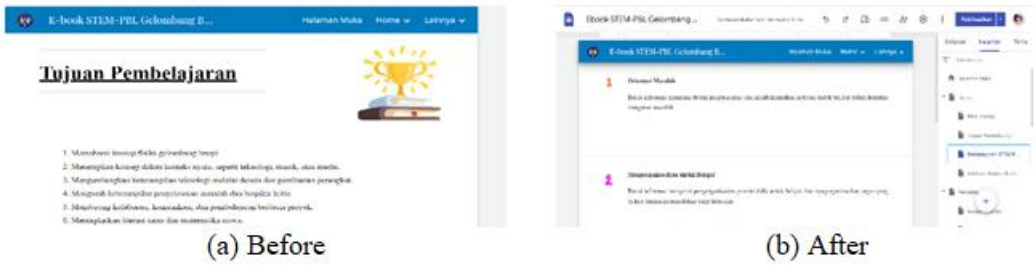


Fig 6. *Display Home Menu Revision*

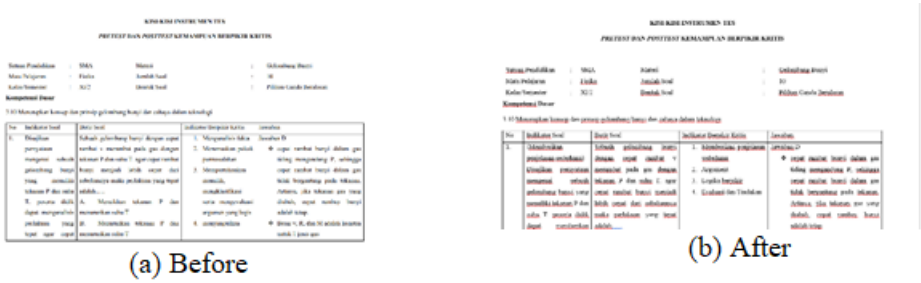
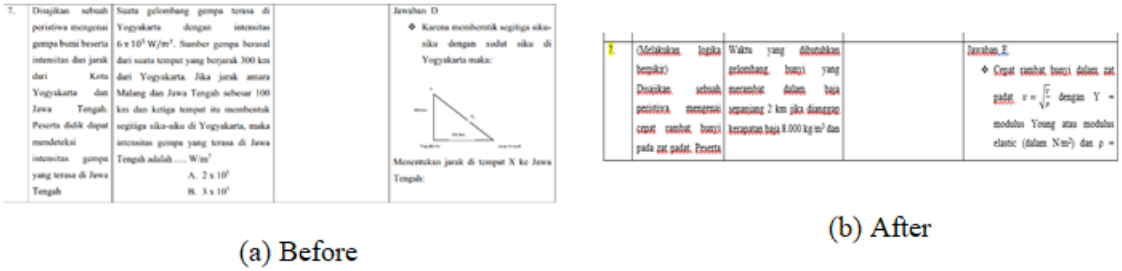


Fig 7. *Display Revision Pretest and Posttest Question Indicators*

Furthermore revise indicators contained in the pretest and posttest instruments, at the beginning indicator question Still messy and not yet clear. It is better given explanation to make it easier reader in read every question.



(a) Before

(b) After

Fig 8. *Revision of Pretest and Posttest Questions*

Furthermore revise on number 7 suggestion from expert For repair or replace question because question No clear and potential confusing participant educate. The development of this e-book, which is supported by the STEM-PBL approach, aims to For give participant educate experience learning differently with use technology moment this. This will make learning more interesting, innovative, and realistic. With a smartphone, this e-book can accessed and studied When only. E-book is tools that can reliable For give impact positive towards the learning process. In the learning process, the class experiment looks more enthusiastic than class others. Concept This can increase desire For gather information, analyze, identify, and solve problem moment learning. Activities This own potential For increase ability think critical and literacy mathematical students. Based on the acquisition results in the form of posttest assessment obtained that mark experiment 1 in category okay, followed by with posttest experiment 2 and class control in the low category. Therefore The use of e-book media based on Google Sites is very Good applied For increase ability think critical and literacy mathematical student.

a. E-Book Media Validation

Results by media experts the validation results are obtained based on the evaluation of material experts against e-book based on the evaluation of material experts agains e-book

Table 4. Media Validation Results by Media Experts

No.	Aspects	Score	Category
1.	Display	83,78	Very worthy
2.	Instructional	72,43	Deserving
Average overall aspects		**78,10**	**Deserving**

Based on a table, e-books based on google sites with STEM-PBL approach to sound wave material in high validation categories with good and of use categories.

b. E-book Validation Results by Material

Expert the validation results are obtained based on the evaluation of material experts against e-books based on google sites with the STEM-PBL approach. The results of material validation by material experts can be seen in the annex.

Table 5. E-book Validation by Material

No.	Aspects	Score	Category
1.	Content/material	90,5	Very worthy
2.	Text/content	71	Deserving
Average overall aspects		**80,75**	**Deserving**

Based on the table, e-books based on google sites with the STEM-PBL approach to sound wave material belong in the category high validation with a category so that the e-book can and deserves to be used.

c. Practicality Test Results

A practicality test was conducted to determine the practicality of students against e-book based on google sites on 36 students. There are a number of related aspects of this craftsmanship, namely, the commercial aspect, the aspect of appearance, the characteristic aspect of the e-book, and the operational aspect. This lifting resul can be seen on

Table 6. Results of Google Sites based E-book Practicality Study by Students

No	Student Code	Total Score	Ideal Score	Category
1	A1	50	60	Very Practical
2	A2	49		Very Practical
3	A3	52		Very Practical
4	A4	51		Very Practical
5	A5	48		Practical
6	A6	48		Practical
7	A7	48		Practical
8	A8	51		Very Practical
9	A9	53		Very Practical
10	A10	49		Very Practical
11	A11	60		Very Practical
12	A12	41		Very Practical
13	A13	50		Very Practical
14	A14	53		Very Practical
15	A15	48		Practical
16	A16	50		Very Practical
17	A17	51		Very Practical
18	A18	49		Very Practical
19	A19	50		Very Practical
20	A20	50		Very Practical
21	A21	60		Very Practical
22	A22	53		Very Practical
23	A23	57		Very Practical
24	A24	56		Very Practical
25	A25	52		Very Practical
26	A26	54		Very Practical
27	A27	60		Very Practical
28	A28	51		Very Practical
29	A39	51		Very Practical
30	A30	54		Very Practical
31	A31	49		Very Practical
32	A32	55		Very Practical
33	A33	52		Very Practical
34	A34	57		Very Practical
35	A35	50		Very Practical
36	A36	50		Very Practical

Based on the data obtained, it can be concluded that the trial is limited to seeing the practicality of e-books based on google sites developed gain practical category. If reviewed on each student, on the practicality test only A5, A6, A7 and A15 obtained a score of 80 with the practical category. Several tests have been carried out and at this stage the product has already received values from the validator and has already obtained values of the pupils, then at the development stage this is considered to be completed. Once this phase is complete, the product is ready to be implemented in the trial class.

1) Critical Thinking Normality Test Results and Mathematical Literacy

The normality test is performed to determine the data obtained on each bound variable for three normal-distributed classes. This test uses the Shapiro-Wilk Test On SPSS 23. The data is distributed

when asymp.sig (2-tailed) > 0,05

Table 7. Variable Normality Test Results

Test Type	Class Type	Test Type	Significance
Pretest	Experiment 1	Shapiro-Wilk	0,084
Posttest	Experimentt1		0,472
Pretest	Experiment 2		0,059
Posttest	Experiment 2		0,062
Pretest	Control		0,669
Posttest	Control		0,651

Based on the results of the table, it can be concluded that all data from the entire class are normally distributed, seen on data of significance greater than 0,05 (Sig > 0,05). Then a multivariate normality test is performed to see if the data 176 is normally distributed for the entire data acquisition. As for the multivariat normalization test, the result can be seen on the SPSS output of the Mahalanobis and Chi-Squared sections with Pearson Correlation values. If the Pearson correlation value is > 0,05, then the whole data is distributed normally.

Table 8. Results of the Multivariate Normality Test

Output	Pearson Correlation	Sig. (2-tiled)
Mahalanobis	0,989	0,000
Chi-Squared	0,989	0,000

Based on the results of the multivariate normality test obtained a cost value of 0.989 > 0.05 and a chi-square of 0,000 < 0.05. That means the entire data acquisition ranging from critical thinking skills to pretest and posttest as well as mathematical literacy to pretests and posttests has been distributed normally. It also corresponds to the output of a scatter graph that forms points of a straight line like in the picture. The graph shows that the data obtained from the field test is already normally distributed according to Figure 9.

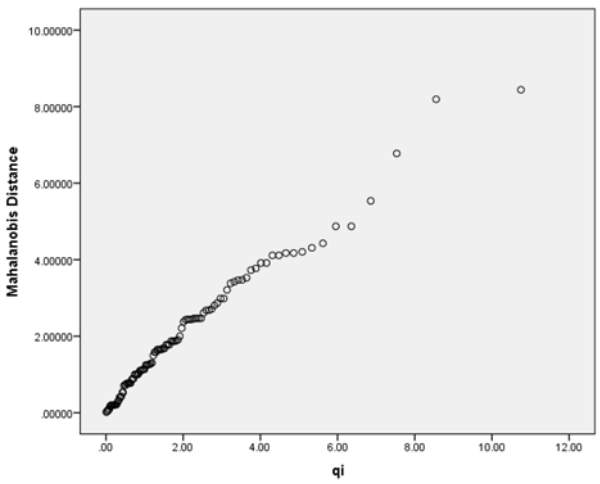


Fig 9. *Cheap bus and Chi-Squared Scatter Graphics*

2) Homogeneity Test Results

The homogenity test is obtained from the Levene test to test the similarity of the sample, i.e. homogeneity or absence of data variants from the population of the third group for each bound variable. The homogenity test results can be seen on Table 9.

Table 9. The homogenity test results

Binded Variables	Type of Test	Significance
Critical Thinking Skills	Levene's test	0,645
Mathematical Literacy		0,524

Based on Levene's test results in Table 9 showed that the acquisition of significance values on critical thinking and mathematical literacy > 0.05 resulted in that data variance was homogeneous. A multivariate homogenity test is then performed to determine whether the data is homogeneous or non-homogenous. The 178 test used the GLM test by looking at the output on the Box's M part. When the Sig Box's M > 0.05 data is homogeneous. The multivariate homogenous test results can be seen on Tabel 10.

Table 10. Results of Multivariate Homogenity Test

Output	Value
Box's M	4,624
F	0,749
df1	6
df2	274776,923
Sig	0,610

Based on the output of the table that sig > 0.05 means the total data is derived from the data that is homogeneous.

Discussion

1. Product Description

The e-book based on Google sites with the STEM-PBL approach developed is expected to be able to be a solution to the difficulties of teachers and students in the learning process specific material sound waves. The development of e-books based on google sites is operated online through smart phones or other electronic devices that students own. The use of google sites on this e-book is one of the uses of technology accurately and well because it is equipped with learning materials, video learning, simple LKPD, topic training, so it is expected to be able to enhance critical thinking skills and mathematical literacy of students.

The purpose of the development of interactive e-book fsika based on STEM-PBL provides a different learning experience by utilizing existing technology so that learning is more interesting, innovative and realistic for pupils. This e-book can be accessed using a smartphone so e-books can be studied anytime and anywhere. This medium can be used as a potential and effective medium to give a positive influence to the learning process. It can be seen at the time of learning activities. Experimental class pupils using STEM-PBL-based interactive physics e-books were more active and enthusiastic compared to experimental class 2 and control class who looked bored and less interested in learning. The enthusiasm and interest in the experiment class enabled them to gather information, analyze, identify, and solve problems at the time of learning. The attitude to such activities can improve the critical thinking and mathematical literacy of the pupils. Based on the acquisition of the results of the posttest assessment, it is obtained that the value of experiment class 1 obtains a value in a good category while the other classes are in a lower category. Therefore, the use of e-book media based on google sites is excellently applied to improve critical thinking skills and mathematical literacy of students.

2. Product Validity

The validity of e-book products based on Google sites on sound wave material with the STEM-PBL approach was previously validated by two expert validators and material validators. It aims to find out the validity of the media that has been made before using the field trial. Advice and input from experts as media and material improvements. Here's the validation display on Figure 10.

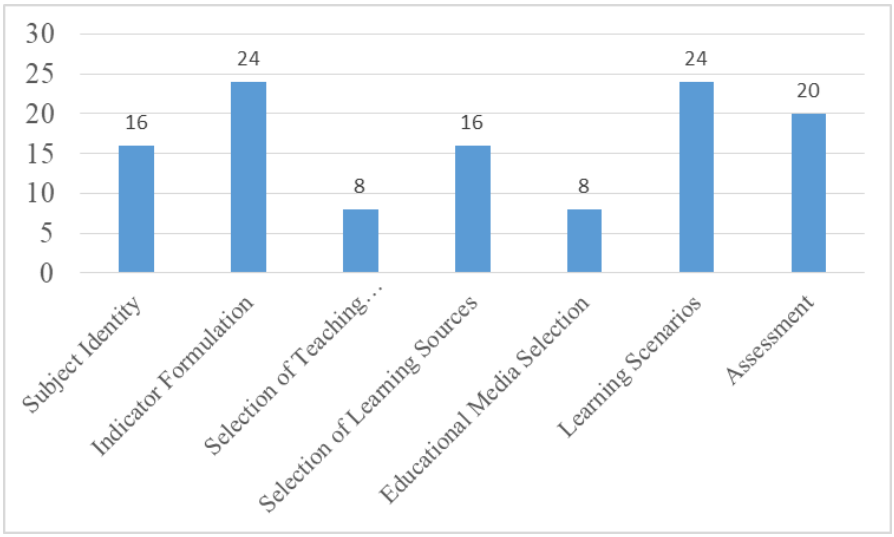


Fig 10. *Media and Material Score Achievement Bar Diagram*

Based on Figure 10, the results of the media expert validator and the material developed get a high category. The material performance can be seen on the left side bar diagram on the contents/material aspects 181, 55, contents 87, maximum score 200 and V'aiken 0.78. While the media part can be viewed on the right side of the display aspects 155, instructional aspects 134, maximum score 185 and V'aiken 0,72.

3. Product Practicality

The practicality of the e-book media is based on the evaluation of physics teachers using e-books. The teacher said that e-books based on google sites are already in line with the development of IPTEK and have features that are easy to understand and interesting and can be a solution for students to use smartphones more intelligently. The use of STEM-PBL also on sound wave material can increase student interest as students become more active in discovering events that they are not aware of through questions and short questions on google sites. The opinion is in line with the opinion [15] [16] [17] [18] [19]. It is also proved by the achievement of the practicality score of the product filled by the pupils after using the developed product. The product obtained a very practical score from 34 pupils and 2 practical answers.

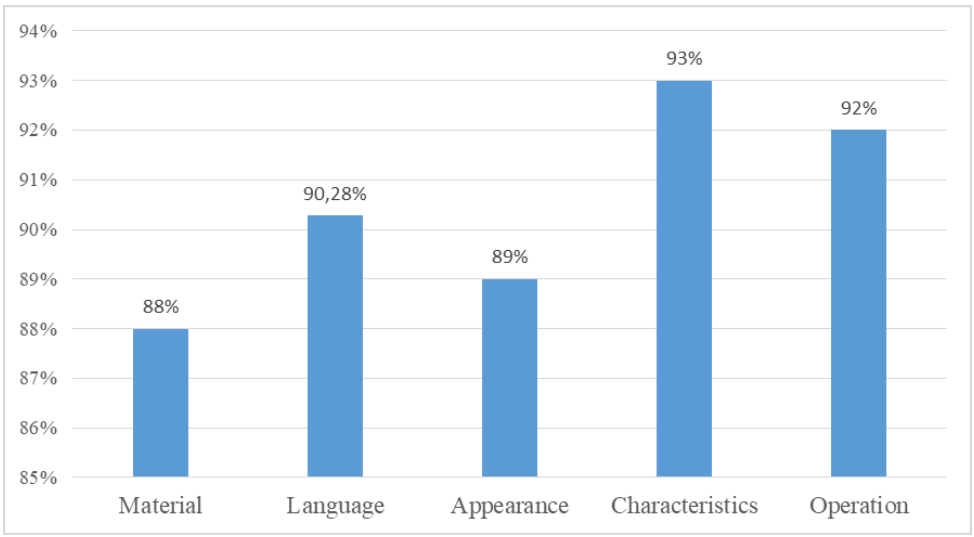


Fig 11. *Acquisition of Product Practicality Scores*

4. Product Effectiveness

Product effectiveness is a measure of product success developed by e-book based google sites with STEM-PBL approach in improving critical thinking ability and mathematical literacy of participants through field trials. The field trial consists of three groups of samples, namely, experiment class 1, experiment class 2, and control class. Experiment class 1 is a class that uses e-books based on google sites with the STEM-PBL approach, the experiment class 2 uses a STEM model with LKPD teaching media, while the control class uses school textbooks or conventionally.

a. Critical Thinking Ability Difference Experimental Class 1, 2 and Critical Thought Ability Control Class

Thought Ability Control Class have been conducted field trials on three different classes of megalithic improvement. Average increase in critical thinking skills values shown in the picture

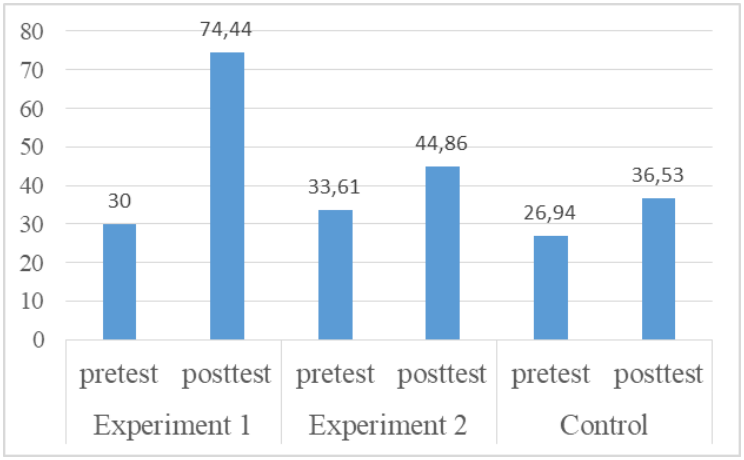


***Fig 12.** Differences in critical thinking skills in each class*

Based on Figure 12, the improvement in critical thinking ability can be seen from the calculation of pretest scores, posttets, and N-gain values. Critical thinking skills in experiment class 1 are better than in other classes. It shows that the use of e-books based on google sites with the STEM-PBL approach is very effective in increasing students' ability to think critically.

b. Difference in Mathematical Literacy Class 1, Experiment 2, and Control Class

Here's the test results on mathematical literacy in three different classes, with the type of test pretest and posttest.

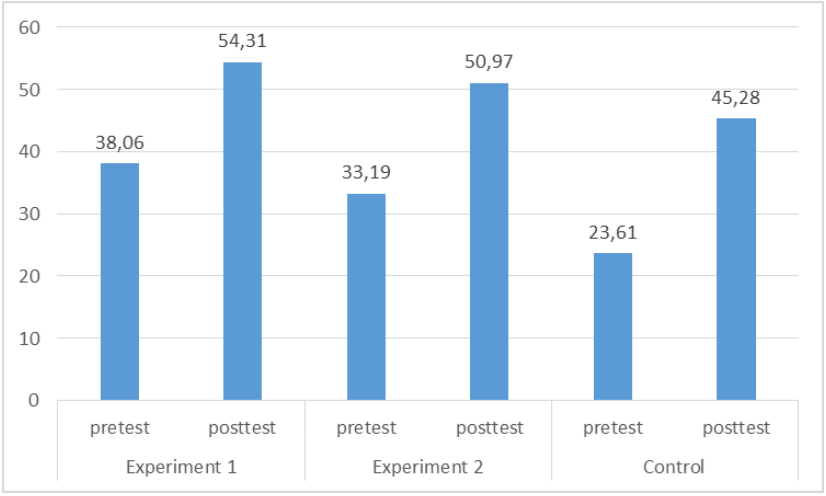


***Fig 13.** Data on Differences in Mathematical Literacy Abilities For Each Class*

This research is based on critical thinking skills indicators such as giving basic explanations, interpreting and analyzing in written form, proposing formulas and determining solutions, using mathematical symbols, using technological tools. Thus, these pupils have demonstrated significant ability in mastering the mathematical literacy required **Error! Reference source not found.**. The demands of mathematics students not only have the ability to calculate, but the logical and critical ability to solve matters must also be possessed by students.

However, in this study it was found that most of the students did not rewrite what they found. In another study it was mentioned that most students have not yet been able to interpret mathematics back into real context.

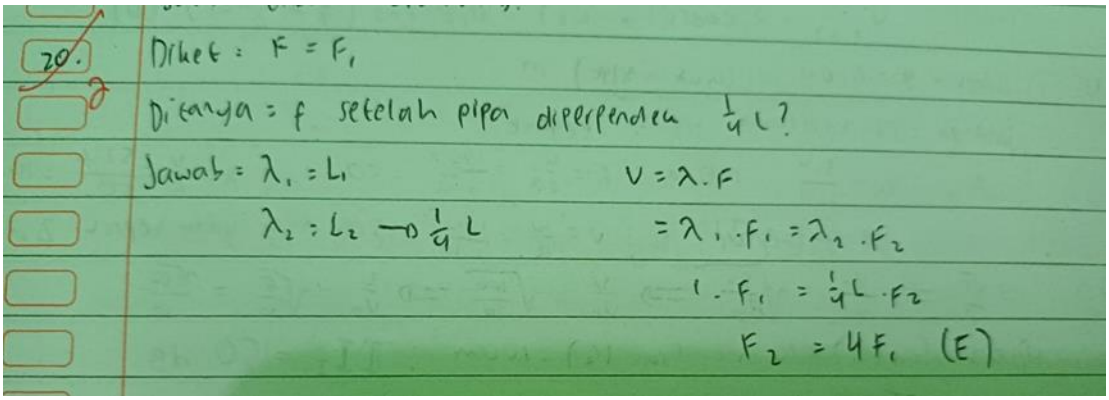


Fig 14. *Results of students work 1*

Based on the completion of the subjects of the student 1, the results of the work of student 1 show that he is able to recognize the dominant idea of the problem well, mention what is known and what is asked correctly, complete and simply. These students are also able to choose and find ways to solve problems. But the alternative answer doesn't write the steps of settlement with a mess. One study conducted by Yohannes et al [42] suggests that mathematical literacy is an important part of learning.

However, conventional learning methods often have difficulty developing this mathematical literacy. As a result, many students experience 197 difficulties in understanding problems on a particular topic of discourse somehow in learning even in the real world. After being tested on 34 students, there was a significant difference in mathematical literacy. Classes that use e-books are superior to conventional classes. Although the differences are not very significant but the general understanding of reading, mathematical knowledge and mathematics skills of the class that uses e-books are more dominant. Nurlan et al [12] explained that mathematical literacy skills are essential for learners who want to solve various problems in life.

c. The Impact Of Google Sites Based E-books On Sound Wave Material With The STEM-PBL Approach To Enhance Mathematical Literacy and Critical Thinking Skills

The results of the field trials showed that the mathematical literacy and critical thinking skills of experimental class 1 were better compared to experimental classes 2 and control classes. This is supported by the Manova statistical test results which have a significance of 0,000 < 198 0,005 so that it can be concluded that H0 is rejected and H1 is accepted. It is also in line with previous research that there is an influence of e-books on critical thinking and literacy [43] [44] [45] [46].

Similar surveys were also conducted by previous researchers explaining that there is an increased mastery of concepts and critical thinking due to the use of educational media such as google sites [6] [7] [8] [9] [10]. Based on this, it can be concluded that e-books based on Google sites on sound wave material with the STEM-PBL approach are effectively used in physics learning to enhance mathematical literacy and critical thinking.

CONCLUSION AND SUGGESTION

Conclusion About The Product

Based on the results of research and development of Google Sites-based e-books using the STEM-PBL approach, sound wave material can be drawn
as follows:

1. Feasibility of Google Sites-based e-books with a STEM-PBL approach to sound wave material to improve mathematical literacy and critical thinking skills:
   a. Google sites based e-book with STEM-PBL approach to sound wave material is feasible based on feasibility assessment by experts based on appearance and instructional aspects.
   b. Google sites based e-book with STEM-PBL approach to sound wave material is feasible based on feasibility assessment by material and media experts
   c. Google sites based e-book with STEM-PBL approach sound wave material is feasible based on practical aspects for students
2. The practicality of a Google Sites-based e-book with a STEM-PBL approach to sound wave material to improve mathematical literacy and critical thinking skills:
   a. E-book based on Google sites with a STEM-PBL approach with practical sound wave material used in learning according to the teacher
   b. Google sites based e-book with a STEM-PBL approach, practical sound wave material used in learning according to students based on aspects of material, language, appearance, characteristics and operation.
3. The effectiveness of a Google Sites-based e-book with a STEM-PBL approach with sound wave material to improve mathematical literacy and critical thinking skills: it is stated that this e-book is effective in improving students' mathematical literacy and critical thinking skills.

Product Suggestions and Use

The following suggestions and utilization of e-book products based on Google Sites with the STEM-PBL approach that have been developed are:

1. Google sites based e-books with a STEM-PBL approach using sound wave material to improve mathematical literacy and critical thinking skills can be used as a teaching media reference that has been tested for feasibility, limited trials and field trials.
2. Further research could develop e-book products based on Google sites with a STEM-PBL approach to other physics materials.

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