Development of Knowledge Enrichment Digital Book of Tectonic Earthquake

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Abstract

This research aims to develop a digital knowledge enrichment book about tectonic earthquakes. Useful for study concepts of waves, elasticity, and Hooke's law. This research method uses the ADDIE (Analysis, Design, Development, Implementation and Evaluation). The validation scores of material experts, learning experts and media experts are in the high category. This digital book has been tested on 49 physics students at San Pedro University, Kupang, Indonesia, and the results are positive. All respondents can enjoy reading this book, increasing their knowledge, and the contents of the book can be understood easily. The test results for this book received a very good assessment in the media aspect, formulating the main problem, revealing facts, choosing arguments logically, and detecting information bias in the book. All respondents were able to draw conclusions from the book and the book was not boring. So, this book can be used as an effective learning resource.

Keywords: knowledge enrichment, digital book, tectonic earthquakes.

INTRODUCTION

Physics is a science that studies natural phenomena at a basic level; its logic makes a lot of sense because it is in accordance with our daily experiences, while at an advanced level physics can be used to predict natural behavior or natural phenomena that will occur (Utami, 2014). One of the natural phenomena that can be studied is tectonic earthquakes.

The meeting of the Indo-Australian Plate, the Eurasian plate, and the Pacific plate makes Indonesia an area prone to earthquakes. The Indo-Australian plate which is moving relatively north meets the Eurasian plate so that it intrudes into it, while the Pacific plate moves relatively westward. The earthquake that occurred has the potential to cause a tsunami because the plates meet at sea (BMKG, 2019), coupled with a coastline length of 99,000 km, Indonesia has quite a lot of tsunami-prone areas. Areas that are prone to a tsunami disaster are areas directly facing the confluence of the Eurasian, Indo-Australian and Pacific plates, including the western part of Sumatra Island, southern Java Island, Nusa Tenggara, the northern part of Papua, Sulawesi, and Maluku, as well as the eastern part Kalimantan Island (Alfiani, 2016).

This condition is a problem that will always haunt the people of Indonesia every year. This is the reason for young people to realize that understanding and studying this phenomenon is needed for the life of the next generation. Therefore, it takes knowledge and insight obtained from education. According to the Regulation of the Minister of Education and Culture Number 37 of 2018 Concerning the 2013 Curriculum for Senior High School/Madrasah Aliyah, in the Curriculum Structure section, precisely in the 3rd Core Competence section, it is explained that students must be able to solve problems by utilizing the knowledge and insights gained during the learning process (Permendikbud, 2018).

The problems described above can be poured into the learning process through an enrichment program. At the Minister of Education and Culture No. 104 of 2014 concerning Assessment of Learning Outcomes states that those who are successful can be given an

enrichment program according to the time available both individually and in groups (Permendikbud, 2014). The enrichment program is a deepening or expansion of the competencies learned.

There are three types of enrichment books, namely: personality enrichment books, skills enrichment books and knowledge enrichment books. Personality enrichment books are books that contain material that can help shape personality. skills enrichment book is an introductory book of learning materials to improve mastery of skills in a particular field. Information enrichment books are books that contain more knowledge, understanding and experience of the reader. In this research a knowledge enrichment book was developed (Adriani, Subyantoro, & Mardikantoro, 2018).

By developing an enrichment book, students can realize independent learning from the students themselves, not from what is conveyed by the teacher. Thus, students are expected to be independent in acquiring knowledge (Putri, 2019). The knowledge enrichment book developed has an acceptable value based on the four criteria for evaluating the enrichment book, namely material, presentation, language, and graphics (Kurniawati, 2017). In addition, knowledge enrichment books can be an aspect of strengthening the character education of Indonesian students (Rozani, 2020).

A Digital or Electronic Book is an application composed of text, images, and audio and video that is published in digital form and read on computers and other electronic devices (Aprilia, Sunardi, & Djono, 2017). According to Ruddamayanti (2019) electronic books are electronic versions of books that contain digital information which can be in the form of images, text, or videos. Based on the explanation above, it can be synthesized that an electronic book is an application that displays text, images, videos, and animations in book form and is published in digital form for reading by computers or other electronic devices.

According to Crider, E-books (electronic books) are book publications available in digital form consisting of text, images, or both, which can be read on a computer screen or other electronic device (Gardiner, Eileen, & Ronald, 2019). In e-books, electronic bookmarks facilitate

referencing, and e-book readers allow users to bookmark pages (Brown, 2016).

E-books allow users to browse books online, and by selecting and ordering titles, the e-books can be delivered to them online or the e-books can be downloaded (BBC, 2017). The main reasons for buying e-books are likely to be lower prices, greater convenience (as they can purchase at home or on the go with their mobile devices) and a wider selection of books (Bhardwaj, 2015).

An earthquake is an event where the earth vibrates or shakes due to the sudden movement/shift of the rock layers in the earth's crust due to the movement of tectonic plates. Earthquakes caused by the movement of tectonic plates are called tectonic earthquakes. An earthquake (tremor) is a vibration of the earth's surface caused by sudden energy pressure in the earth's lithosphere, producing seismic waves (Ohnaka, 2013). Whereas tectonic earthquakes occur anywhere on Earth that has enough stored elastic strain energy to promote the propagation of cracks along crust planes (O'Hara & Kieran, 2018).

The sudden movement of rock layers in the earth produces energy that is emitted in all directions in the form of earthquake waves or seismic waves. When these waves reach the earth's surface, the vibrations can damage everything on the earth's surface such as buildings and other infrastructure so that it can cause loss of life and property. In contrast to volcanic eruptions and other natural disasters, which are preceded by signs or symptoms that appear before the incident, earthquakes always come suddenly and startle, causing extraordinary public panic because it is completely unexpected so that no one who had time to prepare (Marsita, 2021). The outermost layer of the earth's crust or lithosphere consists of tectonic plates that are rigid and float on rocks that are relatively non-rigid and move one over the other. The area where two plates meet is called a plate margin or plate boundary, which can be a subduction zone, the spreading of the ocean floor, or uplifting, folding, etc. in the collision zone. Earthquakes cannot occur anywhere, but they generally occur around plate boundaries, which form the world's earthquake pathways, and around faults.

If two plates meet at a fault, they can move away from each other, approach each other, or

slide over each other. Generally, this movement is slow and cannot be felt by humans but is measured at 0-15 cm per year.

Sometimes the movement of these plates gets stuck and interlocks so that an accumulation of energy occurs which continues until at some point it is no longer able to withstand the stress, so it breaks suddenly and releases energy in the form of vibrations which we know as earthquakes. There are three possible movements of one tectonic plate relative to another plate, namely if the two plates move away from each other (spreading), approach each other (collision) and slide (transform) each other (Marsita, 2021).

The model to be developed is an earthquake electronic knowledge enrichment book as a learning medium in the enrichment program. The development of electronic knowledge enrichment books is inseparable from several aspects of the assessment that will determine the quality of the book, namely the aspects of material, presentation, language, and graphics. The basic component of developing an enrichment book consists of three parts, namely the front section, the material or content section, and the final section. The title on the cover and front page, copyright page, preface and table of contents fill the front. The material section consists of a description of the book material.

This research aims to develop a digital knowledge enrichment book about tectonic earthquakes. The benefit of this research is that we can understand the application of the concepts of waves, elasticity, and Hooke's law to tectonic earthquakes. So, physics students can use this enrichment book for studying mechanics' subject.

Based on the things that have been stated above, it is necessary to develop a knowledge enrichment book about tectonic earthquakes that is suitable for use as a learning medium for students at the University of San Pedro Kupang, NTT, Indonesia.

METHOD

This research was conducted at the University of San Pedro Kupang, NTT for 10 months in 2023, from proposal writing to research reports. Apart from that, this research also links with related institutions, namely LPPM UNJ and where a trial use of this book was

conducted on 49 students at the University of San Pedro Kupang in April 2023. The following is a development research design flow with the ADDIE model.

This research method uses the RnD (Research and Development) ADDIE development model (Analyze, Design, Development, Implementation, and Evaluation) (Figure 1).
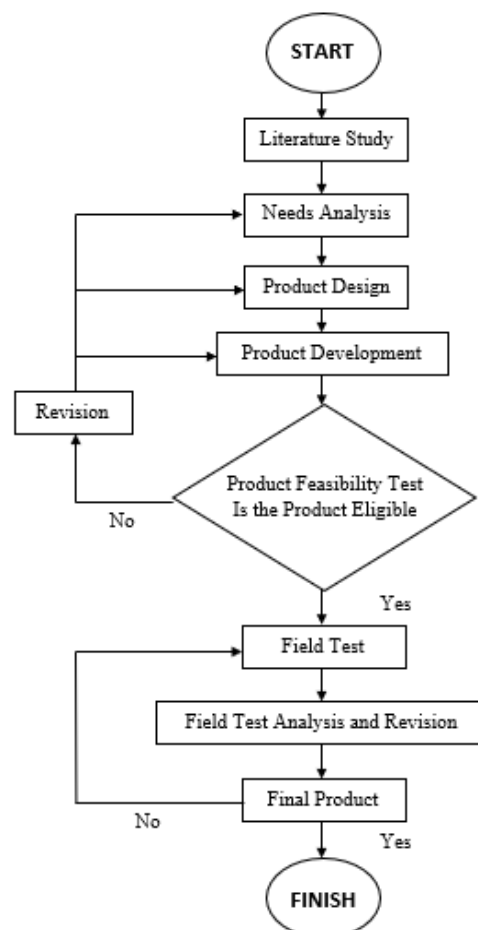

Figure 1. Design research and development flow using the ADDIE model

Several learning system design models or approaches that can be used to design and develop learning programs (Branch, 2018). One model or learning system design approach that can be implemented to design and develop an effective and efficient training program is ADDIE. The design capital of the ADDIE learning system is simple and can be carried out in stages or systematically to create a comprehensive training program (Branch, 2018).

In this ADDIE model where evaluation is carried out at each stage of Analyze, Design, Development, and Implementation.

A. Analysis
Needs Analysis

A needs analysis was carried out to obtain information related to the need for digital knowledge enrichment books on tectonic earthquakes for students at the University of San Pedro Kupang, Indonesia. From the survey results it was found that 100% had computer or laptop facilities to be used as a support in learning activities, 75.4% were more interested in learning media which included videos, pictures, and animations and 69.2% wanted electronic enrichment books.

Thus, the developed tectonic earthquake digital knowledge enrichment book must be easily accessed by students through digital platforms on various devices and operating systems, browsers, or common devices used by students. In addition, the material presented in the book that you want to develop must also be relevant to students' needs in understanding tectonic earthquakes, including concepts, various theories, and applications that are relevant in everyday life, as well as accurate and supported by trusted sources.

Material Analysis

After conducting a literature study of books, journals, articles, and literature related to earthquakes, it was found that the physics material contained in the contents of the book material is wave material, elasticity, and Hooke's law.

When two plates meet, there are three possibilities that can occur, namely the two can move away from each other, the two can shift, and the two can collide with each other. When the two plates collide, one plate will push the other plate. This event is called Stress because there is a force acting on every unit area. If the collision results in a change in shape or size, then this is called Strain.

The sound of Hooke's Law is "If the tensile force does not exceed the elastic limit of the spring, then the change in the spring is directly proportional to the force exerted on the object." If a tectonic plate of the earth gets a force, then Hooke's Law only applies along the elastic area up to the point where it shows the limit of Hooke's Law. When the applied force exceeds the elastic limit of the plates, plate fractures will occur which cause tectonic earthquakes.

An earthquake is an event where the earth vibrates or shakes due to the sudden movement/shift of the rock layers in the earth's crust due to the movement of tectonic plates. The movement of these plates produces two waves, namely body waves consisting of primary waves which are longitudinal waves and secondary waves which are transverse waves and surface waves consisting of Rayleigh waves which are waves propagating on the ground surface where soil grains move ellipses with vertical motion and waves. Love which is a wave that propagates only on the ground surface where the soil particles move transversely in the horizontal plane.

B. Design

At this stage what is being done is to design an electronic knowledge enrichment book that will be developed. The materials are organized into several chapters and each chapter consists of sub-chapters. The compilation was carried out based on searching for information in articles, journals, books, and other literature related to earthquakes. Then, rearrangement is carried out regarding visual design (quality, visual style, and readability of text or symbols). Where, visual design needs to support and clarify the concept of complex tectonic earthquakes, supported by the layout and elements used in the book.

C. Development

The components contained in the electronic module require some software. The software used includes:
a. The text was developed using Microsoft Office Word and Microsoft Office Power Point.
b. Images were developed using Adobe Photoshop and Microsoft Office Power Point software.
c. Video supporting learning material is edited using Wondershare Filmora software which is saved in MP4 format.
d. Animation and simulation as a form of illustration of the contents of learning media material can be obtained via the internet in SWF format.

The final stage of the development of this electronic module is to combine all media and text components into 3D PageFlip Professional 1.7.7 software which is saved in EXE or HTML format.
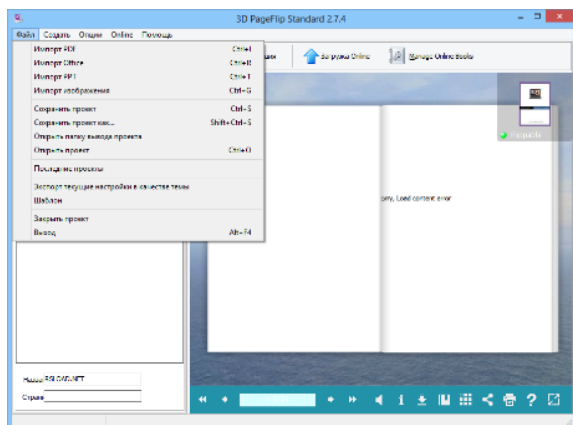

Figure 2. 3D PageFlip Professional 1.7.7 software
(https://images.app.goo.gl/8ufiTVMoA7PPXqam9)

Then, the content quality was improved regarding complicated concepts that became the flow of information in enrichment books which were made shorter and denser. Thus, the user will have a deep understanding of the information read. Apart from that, checking and improving the accuracy of language is also carried out, so that complex information conveyed can be easily understood by readers.

D. Implementation

At the implementation stage, product designs that have been tested by experts are implemented to students at the University of San Pedro Kupang. Then, giving a questionnaire that refers to the Center for Curriculum and Books to students as a product test. The results obtained after making improvements to the previous stage, namely the features in the media, can be used properly (as expected). Then, students can easily access digital enrichment books and easily find the information they need. In addition, this book is also related to electronic devices, such as cellphones and laptops. The results from the trials: 100% of students enjoyed reading this book,100% stated that they could increase their knowledge, and 100% stated that easily understood the contents of this book. 100% stated that the media was very good, 100% of students can formulate the main issues, 100% of students can reveal facts, 100% of students were able to choose arguments logically, 100% of students can detect information bias in this book, 100% of students were able to draw conclusions, and 0% said this book was boring.

E. Evaluation

The evaluation stage is the stage that determines whether this digital book is appropriate to be developed so that it can be used as a learning resource. At this stage, seeing how much the acceptance of this product has been to students through the questionnaire given and seeing the development of students' insights and knowledge by holding questionnaires related to the use of this digital book.

To obtain the necessary data, the following data collection techniques were used: literature study, observation, material experts, media experts, and learning experts, University of San Pedro students, and lecturers at the University of San Pedro.

Instruments used in this study include computer hardware, computer software, questionnaires, and validation for due diligence with instrument grids. In the pre-test and post-test, test the validity of the instrument, test the reliability of the instrument, test the level of difficulty and test the power of difference. At this stage, the normality test, homogeneity test, N-gain test, and T test are carried out. It is hoped that the existence of this digital knowledge enrichment book on tectonic earthquakes can improve the results of students' creative thinking abilities. The learning method that is suitable for this tectonic earthquake material is the discussion and question-answer method, both online and offline.

RESULT AND DISCUSSION

Based on the steps of the research and development model, the development results are as shown in Figure 3-8:

Figure 3. Book Cover

Figure 4. Table of Contents

Figure 5. Front View of the University of San Pedro.

Figure 6. Side view of the University of San Pedro.

Figure 7. During Trial 1

Figure 8. During Trial 2

After the media development stage, implementation was carried out by testing physics students at the University of San Pedro Kupang. Before being tested, physics students at the University of San Pedro Kupang were given a pretest first, then physics students at the University of San Pedro Kupang were given a digital book on tectonic earthquakes to read. After reading the digital book on tectonic earthquakes, Physics students at the University of San Pedro Kupang filled out a questionnaire provided by the Google form (link gform).

The results of the media feasibility test questionnaire in the image above explain, as follows:

a. A total of 49 students stated that the knowledge enrichment book on tectonic earthquakes with a physics perspective is fun to read,
b. The students also stated it can increase knowledge,
c. It is easy to understand,
d. the media (such as videos, presentation of text, and pictures) in this digital book is very good,
e. students can formulate main points -the subject matter of tectonic earthquakes,
f. students can reveal existing facts,
g. students can choose logical arguments,
h. students can detect bias: do tectonic earthquakes or volcanic earthquakes have different points of view,
i. and students can draw conclusions.
j. There were no students who stated that reading books on enriching knowledge of tectonic earthquakes from a physics perspective was boring. So, this book on enriching knowledge of tectonic earthquakes from a physics perspective was not boring.

In the earthquake digital enrichment book, it is explained that Indonesia is one of the countries prone to earthquakes because Indonesia is traversed by the meeting point of four of the world's major tectonic plates, namely the Philippine Sea Plate, the Indo-Australian Sea Plate, the Eurasian Plate, and the Pacific Plate. This is in line with the results of research conducted by (Metrikasari & Choiruddin, 2021), that Indonesia's geographical location at the confluence of three tectonic plates and the Pacific Circumferential Path has caused Indonesia to become one of the countries with a high risk of earthquakes and one of its regions is Sumatra. This is due to the geographical location of the island of Sumatra is traversed by faults, volcanoes, and subduction zones (Metrikasari & Choiruddin, 2021).

The earthquake digital enrichment book also explains the seismic method. The seismic method is a geophysical technique used to measure the propagation of seismic waves that propagate within the earth. The seismic waves captured by the seismograph array are formed from artificial earthquakes that occur in certain places. So, from this it can be analyzed the nature of the material composing the structure of the earth. Seismic waves themselves are divided into two, including p waves (primary) and s waves (secondary). The same thing was also explained (Valeria, 2018), that seismic waves are divided into two, namely body waves and surface waves. Then, body waves are divided into two,

including primary waves (P waves, compression waves) and secondary waves (S waves, shear waves) (Valeria, 2018). Characteristics of Soil in the Bandung Basin Based on Shear Wave Velocity (Vs30) with the MASW Method (Multichannel Analysis of Surface Wave).

The earthquake digital enrichment book provides an explanation of the requirements for an earthquake to cause a tsunami, namely the epicenter (the location of the epicenter of the earthquake is in the sea), the hypocenter (the depth of the epicenter of the earthquake is less than 60 km from the seabed), the magnitude is more than 6.5 SR, reverse fault (a vertical uplifting earthquake fault mechanism) or a normal fault (causing a seafloor shift), occurs in a tectonic plate subduction zone, and forms a sloping beach front. This is in accordance with the literature, "earthquakes with a magnitude of more than 6 SR (Richter Scale) with a depth of less than 60 km, and earthquake faults including falling or rising faults are conditions for the occurrence of a tsunami" (Santius, 2015).

The earthquake digital book also describes the types of earthquakes based on their depth which are divided into three, namely, shallow earthquakes with a depth of less than 70 km, medium earthquakes with a depth of 70 km – 300 km, and deep earthquakes with a depth of 300 kms – 450 kms. This statement is reinforced by the results of research conducted (Silitonga, 2022), that the seismicity map shows how during a 10-year period of tectonic earthquakes that occurred 19 times in South Labuhanbatu Regency with a magnitude of M ≤ 4 SR, the class of earthquakes is as follows:

a) Shallow earthquakes with a depth of less than 70 km and occurred 6 times,
b) Moderate earthquakes with a depth of 70 km-300 km and occurred 11 times, and
c) Deep earthquakes with a depth of more than 300 km and occurred 2 times.

Then, a validation test was carried out on two media experts, two material experts, and two learning experts. Figure 10 shows the results of the validation test for media, material, and learning experts.
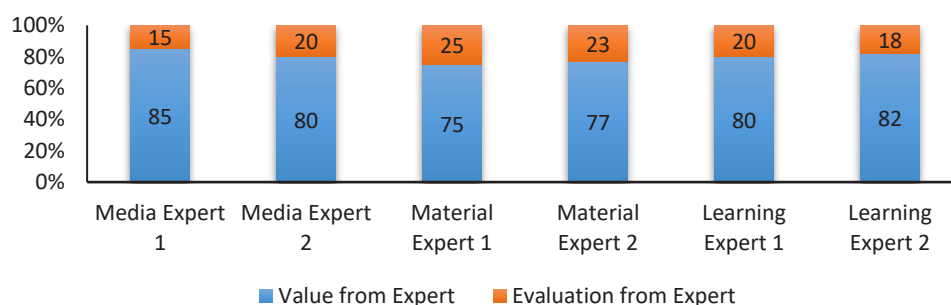

Figure 10. Validation Test Results

From the data shown in Figure 10, the average score given by (1) media expert is 82.5, (2) material expert is 76, and (3) learning expert is 81. The improvement of this media is that the quality of the graphics/animation/pictures in the book needs to be improved again to provide more attractive visuals that can support an understanding of tectonic earthquakes. The improvement from the material expert is about readability and affordability, which needs to be reviewed so that the book can be easily understood by students and the difficulty level of the material can be adjusted according to student understanding Improvements from the learning expert, namely reviewing whether the book supports a student-centered learning

approach so that students can carry out independent exploration, problem solving, and critical thinking about earthquakes tectonics from a physics point of view. Table 1 shows a validation test reference table.

Table 1. Table of Reference for Validation Test Results

No	Symbol	Description	Score
1	VG	Very Good	1
2	G	Good	2
3	NG	Not Good	3
4	VNG	Very Not Good	4

Index calculation is done by the formula:

$$\text{Index value} = \frac{\begin{Bmatrix} (F1 \times 1) + \\ (F2 \times 2) + (F3 \times 3) + (F4 \times 4) \end{Bmatrix}}{4}$$

F1 is a very good answer frequency

F2 is a good answer frequency

F3 is the frequency of answering not good

F4 is the frequency of answering very not good

Meanwhile, the resulting index numbers start from the numbers 24-96 with a range of 72, as follows:

24-48 = Low

49-72 = Moderate

73-96 = High

Based on the reference table validation results, scores from material experts: 76 (high category), learning experts: 81 (high category), and scores from media experts: 82.5 (high category). So it can be stated, that the media, materials, and learning in this earthquake digital enrichment book are very good to be used as learning source.

Serevina said it can determine by using website an e-learning tool on a physics course can increase student creative thinking skills through educational management (Serevina, 2022). In this research, developed knowledge enrichment digital book on tectonic earthquake also can see on Website as learning source. The benefits of this digital enrichment book on tectonic earthquakes in physics learning, especially in earth and space physics courses, sub-material on tectonic earthquakes. The lecture material on tectonic earthquakes still lacks learning resources, so having this digital enrichment book on tectonic earthquakes is very useful for physics students.

CONCLUSION

In this research, developing a digital book to enrich knowledge about tectonic earthquakes for San Pedro Kupang students. So, this developed digital book for knowledge enrichment of tectonic earthquakes can be used as a learning source for students.

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