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Design of Exophysics: Book-Based Mobile Application for Literacy Learning in the Remote Access Areas of Indonesia

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Abstract: The Indonesian Ministry of Education pays much attention to education in remote areas. The lack of equal education and the level of access to education are two main reasons. In remote areas of Indonesia there are still very few educational facilities, either in the form of infrastructure or other facilities, one of which is learning resources. Today's learning resources can only be used in well-developed, easy-to-reach cities. They can't be used in less developed or remote areas. Reports and results of observations from some remote areas state that almost all children have used an Android but not to play games as it was meant to be used. This opens up opportunities, especially for making learning tools that can be used anywhere and anytime without a stable internet connection. This means that children can use them whenever and wherever they want. Therefore, the Exophysics book was designed with this in mind. This study aimed to develop a packaged Android application learning resource using design thinking and scientific literacy approaches. The design thinking phase comprised: (1) empathising, (2) defining, (3) ideation, (4) prototyping, and (5) testing. Five schools in remote parts of Southeast Sulawesi were selected. According to the Ministry of Education, Indonesia, the sample selection was randomly based on the relationships of several teachers, whose areas were included in the underdeveloped region category. To test products with students and teachers as respondents, the teacher sample selection was randomly conducted, involving five teachers, as the first stage of product testing. Learning media development resulted from the Exophysics book, with learning videos and game features, content, and questions. The study of how teachers and students felt about the Exophysics book strongly supports point 4 above: that it should be used as a learning resource. Therefore, exophysics books can be used as learning resources because the design development pays attention to network access needs so that students can use them anywhere and anytime.

Keywords: design thinking, Exophysics book, remote areas.

Introduction

Education in underdeveloped, remote, and the outermost areas is the focus of attention for the Indonesian Ministry of Education, because of the lack of equity in education and the level of access to education, as two main factors. Indonesia's least-developed, remote, and outlying areas still have some infrastructure or other educational facilities, like learning resources. The learning resources currently being developed can only cover urban areas with high accessibility but not disadvantaged, remote, or the outermost areas. In addition, according to reports and observations in some

underdeveloped, remote, and outermost regions, almost all children have used an Android, but not for its intended function, namely playing games. This offers opportunities, particularly in creating educational materials that children can use anytime, anywhere, without a dependable internet connection. That's why the Exophysics book was designed, with just that in mind. This study aims to investigate the development of a learning resource as an Android application that is packaged using a design thinking approach with a scientific literacy approach. The stages of design thinking are: (1) empathise, (2) define, (3) develop an idea, and (4) prototype and test it. Product trials were conducted in five schools in remote areas of Southeast Sulawesi, involving students and teachers as respondents. The result of the learning media development was the Exophysics book, which is equipped with learning video features, games, material, and questions. The answers teachers and students gave about the Exophysics book strongly support point 4 above about how it can help with learning. Therefore, exophysics books can be used as a source of learning because the design and development pay attention to access and network needs so students can use them. However, despite technological advances, many parts of the world still need more access to learning, including Indonesia. According to Arkiang (2021) and Sunarto & Al-Ghifari (2021), the internet network in Indonesia has not reached approximately 31.8% of the country's area, and 7.1% have not been supplied with electricity. In addition, 16.6% of the country that has yet to be connected to the internet are in remote areas, as is 5.9% of the areas still needing electricity. It is certainly contrary to the focus of 21st-century learning. According to the TPACK framework, in the 21st century, learning emphasises using technology as a tool in education. Many factors contribute to this, including the need for more human resources for ICT use and the difficulty of accessing learning media because an online connection is required.

These problems include getting internet access in places that are very far away and have slow connections as well as issues with infrastructure, motivation, the environment, and how students learn. In many remote areas, people also use cell phones, which are not the best tool for learning and require learning support media (Gunarathne et al., 2019; Aditya, 2021). Several things were learned based on observations for about a year in one of the districts in a remote area: (1) even though the area had inadequate internet access, almost all students at the junior and senior high school levels already had mobile phones; (2) most students used mobile phones for social media needs and TikTok; (3) almost all teachers still used books as a source of information and did not involve learning media during the learning process; (4) the learning styles of students who like new things can be important information; (5) students still required digital-based textbooks that could be accessed quickly and used anywhere; (6) learning media still need to be improved (based on an interview with one of the students regarding science or physics lessons) and the learning process rarely involves experiments or the like and most students believe science-physics learning is complex; (7) the characteristics of students who prefer to read in digital form, especially those in which there are videos or simulations, were determined; (8) the characteristics of students who prefer to read directly, via cellphone or digital books compared to non-digital books, were determined; and (9) some teachers lack learning resources that specifically involve scientific literacy in learning.

From these observations, it was found that one of the materials considered problematic and required learning resources was physics. Students at the school assumed that almost all physics subjects are challenging and cannot be understood because they involve many abstract calculations and concepts that cannot be explicitly explained. Many students need more motivation to learn because physics

involves a lot of abstract concepts, and the assignments are complicated and difficult to complete. Because of this, the authors chose to focus one of the main physics topics, waves and light (Jatmiko et al., 2018; Fung & Yip, 2014; Taasoobshirazi & Carr, 2008; Fayanto et al., 2019), because students generally perceive the study of waves as complex, abstract, and uninteresting (Kanyesigye et al., 2022; Xie et al., 2021). In addition, many students need to be aware of the underlying concepts so they can focus on problem-solving strategies (Richardson, 2004).

Therefore, both topics must be presented with a clear vision in order to avoid causing multiple understandings and misconceptions. Materials on wave and light must be presented contextually or in a video as a simulation so that the pattern of light formation and waves can be seen correctly. The videos and simulations are combined into a learning resource packaged in Android form called the Exophysics book. Prioritising design thinking principles based on usability functions led to the creation of the Exophysics book. The Exophysics book was designed as an application format that can be installed on or used on any Android device. The Exophysics book has various learning support media features: materials, simulations, learning videos, and games.

Exophysics books are designed to include literacy elements, especially those related to scientific literacy, given the scope of the discussion related to the material on waves and light. Elements of scientific literacy are included in exophysics books by presenting science as a body of knowledge, a path of inquiry, a way of thinking, and a way for science to interact with technology and society. The material then explains this in several ways, including the use of short statements or questions. Exophysics books are also designed to include learning videos or simulations that can be used offline, making learning easier for students. According to several sources, most learning media must be connected online to be watched (Rodriguez-Paz et al., 2019); learning videos are harder to view offline. This contrasts with exophysics books, where learning videos can be viewed even when not connected to the internet. In addition, at the end of the lesson, exophysics books present quizzes in the form of games to test students' understanding during the learning process.

Furthermore, due to the observations described in the preceding paragraph, the Exophysics book is designed based on student characteristics and learning styles. The Exophysics book presents material directly, using simulations as learning videos to support the material. The Exophysics book can be used easily and it can be used anywhere, even without an internet connection. It is certainly expected to be an alternative learning resource to support the sustainability of physics learning in schools.

In addition, to make the Exophysics book more meaningful, what was developed in it included elements of scientific literacy. Students must master and develop scientific literacy because this is crucial in the current era of globalisation (Nurcahyani et al., 2021; Hartini et al., 2019). Scientific literacy is the knowledge and understanding of scientific concepts and the ability to identify a question and draw some conclusions based on the identified evidence (Oliver et al., 2021; Yacoubian, 2018). However, in the design of the Exophysics book, scientific literacy was presented in the form of science as a body of knowledge, science as a path of inquiry, science as a way of thinking, and the interaction of science with technology and society, in line with several sources on aspects of scientific literacy (Chiappetta & Fillman, 2007; Li et al., 2020).

Research Objectives

Therefore, based on the results of analysis and observation, researchers were interested in developing mobile learning products with basic design thinking according to student needs. This product development used design thinking stages adopted from Canvas, which included: (1) empathy, (2) defining, (3) ideation, (4) making a prototype and (5) testing. Product development aimed to develop a mobile-based learning media product called exophysics books, oriented towards physics learning content for the needs of students in underdeveloped areas. Apart from that, another aim was to provide learning resources that are easy to use and can be accessed anywhere and at any time at a low cost (or freely) to achieve the expected goals. Of course, its implementation has the potential to positively impact the use of learning media, especially in remote areas with all their limitations.

Methods

Research Methodology

Research regarding the development of exophysics books for disadvantaged areas is an approach that combines design thinking with special attention to the social and educational context in these areas. First, we analysed the educational challenges underdeveloped regions face, including limited resources, educational infrastructure, and a lack of access to modern technology. In this phase, we conducted surveys and interviews with the educational community and students to understand their needs better. After identifying the main problems, we designed a prototype Exophysics book suitable for the area's conditions and considering the availability of resources and students' learning preferences. We also integrated elements of inclusive education, ensuring that this book can help improve access to education for all. The final result of this research is an Exophysics book specifically designed for disadvantaged areas, helping to improve education quality and inspiring interest in science in these communities. This approach combined design thinking with awareness of social aspects, to ensure that the resulting product is relevant and effective in a specific context.

Population and Sample

This study involved five teachers and five students from different schools. Sample selection was carried out randomly using relationships that could be accessed easily. The location selection was based on central ministry data regarding disadvantaged areas in Indonesia. Data on disadvantaged areas in Indonesia can be accessed at the following link:

> https://publikasi.data.kemdikbud.go.id/upload/file/isi_D106C225-660A-4208-96A3-7DDD6FDED443_.pdf

The reasons for choosing different schools were:

1) Representation of Diversity: Selecting teachers and students from various schools in disadvantaged areas to ensure that we got views that reflected diverse experiences and educational needs in those areas. Each school may face different challenges and involving participants from various schools helped ensure that products were developed to address a wider range of issues.
2) Contextual Needs: Each school in a remote area may have different educational needs based on available infrastructure, resources and curriculum. By involving teachers and students from various schools, we could better understand contextual differences and design more

relevant and effective exophysics book products. However, it is still only an initial design development at this stage.

3) Inclusive Approach: Bringing in teachers and students from different schools helped ensure that all perspectives and needs were considered in product development. This was an important step in creating an exophysics book that is inclusive and accessible to diverse groups in remote areas.

Tools and Instrument

This research used a survey method, which employed a questionnaire with a Likert scale as the main data collection tool. The questionnaire used in this research was adopted from four previous studies, namely, those conducted by Cahyawati (2015), Nasution (2019), Rahman et al. (2019) and Yudafrisila (2018). This questionnaire measured several key variables relevant to this research's objectives. The Likert scale used in the questionnaire has five response levels, ranging from "strongly disagree" to "strongly agree." Respondents were asked to rate the statements in the questionnaire based on their level of agreement. The use of a questionnaire with a Likert scale allowed researchers to measure the level of perception and views of respondents regarding the variables studied. The data collected through this questionnaire was analysed quantitatively to identify patterns and relationships relevant to this research context. This approach is expected to provide in-depth insight into variables A and B and to support the achievement of the objectives of this research.

Research Procedure

The research method used in developing the Exophysics book used design thinking. Design thinking can be defined as a user-centered approach to innovation (Tan et al., 2022). It was introduced as a management approach to bring creativity and people-centeredness to a new working method. Over time, this concept has become increasingly associated with solving complex and complicated problems, often called "wicked problems." In this research, the design thinking used was by Canva, which consisted of five stages, as presented in Figure 1.

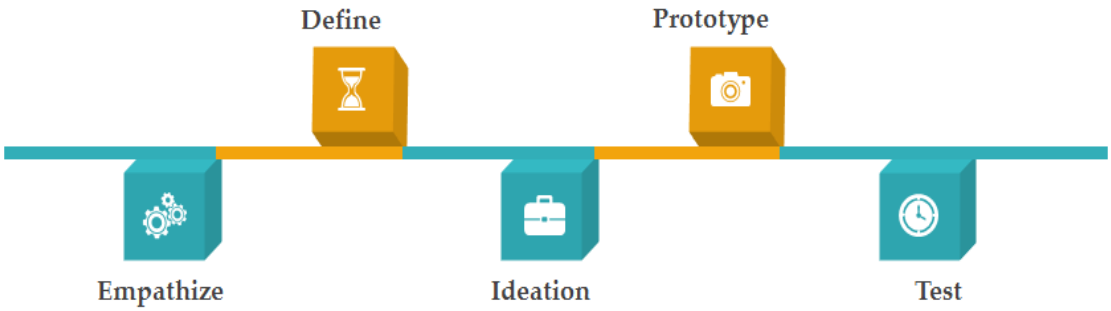

Figure 1: Stages of the development procedure
(Source: https://www.canva.com/learn/design-thinking/)

At the empathise stage, the researcher understands and tries to solve the object's problem. This process involves observing, engaging, and empathising with the person who is the subject of the

problem by understanding the subject's environmental experience to gain a deeper understanding of the problems that occur, especially regarding the needs of the object and its challenges. At this empathising stage, researchers used questions taken from the empathy question in design thinking, which is a series of questions: (1) With whom are we empathising? (2) What do they need to do? (3) What do they do? What do they think and feel? After the researchers received the answers to each question, they moved on to the next stage.

At the defining stage, the problem statement obtained through the empathise process is further formulated. The results of observations related to media needs found that learning resources related to scientific literacy still needed to be improved, especially in physics learning. There were several other findings, as described in the introduction, including: (1) even though the area had inadequate internet access, almost all students at the junior and senior high school levels already had mobile phones; (2) most students used mobile phones for social media and TikTok needs; (3) almost all teachers still used books as a source of information and did not involve learning media during the learning process; (4) the learning style of students who like new things could be important information; (5) students still needed digital textbooks that could be accessed quickly and be used anywhere; (6) The results of an interview with one of the students related to science or physics lessons showed learning media were still lacking in the learning process, which rarely involved experiments or the like, and that learning science or physics was considered difficult by most students, and science or physics lessons and learning media were, by themselves, inadequate. So, as observers, we created a design framework to accommodate the needs associated with this so that researchers could apply learning resources, particularly those related to physics study reference books, which contain aspects of scientific literacy skills.

At the ideation stage, based on the findings at the empathise and defining stages, the researchers tried to create a design framework packaged as a textbook resource. The textbook came from the Exophysics book, which has information that helps students learn about science. There are also simulations and learning videos that can be accessed easily. In addition, the Exophysics book was designed to integrate the truth-order game to reduce student boredom during the learning process and can be used as an evaluation tool at the end of the learning. Of the many findings obtained on this occasion, the researchers focused on waves and light, where the concept is still relatively abstract and requires more explanation, especially concerning the forms used and processes that occur. At this stage, a design mock-up related to exophysics books was produced. Also, at this stage, scientific literacy refered to the indicators formulated by Chiapetta & Filman (2007), which consist of science as knowledge, a thinking process, a process of inquiry, and as interaction between society and technology.

At the prototype and test stages the product was made based on a mock-up from the design stage, which was then packaged as an Android application and tested. The prototype results were tested on a limited basis in several schools in remote areas, involving teachers and students. After being tested, the teacher gave responses related to the resulting product in the form of a questionnaire sheet for teacher and student responses using a Likert scale of 1-4 (1 = disagree; 2 = entirely agree; 3 = agree; 4 = strongly agree) (Cahyawati, 2015; Nasution, 2019; Rahman et al., 2019; Yudafrisila, 2018). These results were then processed to determine how much the developed product can be optimised. Teachers from various district locations and areas that fall into the 3T (remote access area) category were used in this

limited trial. The results of this trial were then analysed descriptively for the product being developed. These results are expected to be used as evaluation materials related to items that will be corrected so that the learning media are created according to the needs and targets of children in remote areas.

Results and Discussion

The design of an exophysics book-based mobile application for science literacy learning in the remote access areas of Indonesia aims to create an innovative and accessible digital learning platform. In remote access areas of Indonesia, where traditional educational resources may be limited, this mobile application was designed to bridge the gap by providing a user-friendly and interactive experience for literacy and physics learning. The app is centered around the Exophysics book, integrating its content and concepts into an engaging digital format. This approach is expected to enhance literacy and physics education and encourage a love for science among students in remote areas. The design of the mobile application focuses on ease of use, interactivity, and adaptability to the local context, ensuring that it can effectively cater to the unique needs and challenges of these remote regions. The project aims to empower educators and students in these underserved areas, ultimately contributing to improved literacy and science education outcomes. This study is limited to the initial development design stage using a design thinking approach.

Based on the design thinking process results, starting from empathise, define, ideate, prototype, and test, an Android-based learning resource application called exophysics books was successfully created. Exophysics books are designed according to the needs of unique learning resources for learning in remote areas. Because exophysics books are based on an Android application that is simple to access without an internet connection and by simply sending files via Bluetooth or other methods, it can certainly have a positive impact, especially in the learning process. Teachers can provide exophysics books to provide learning resources at home. This is because, based on the observations, it was found that almost all children in the village already had mobile phones but their use had not been maximised.

In developing design thinking, the developer tried to choose an area of physics that is considered quite urgent, namely, the topic of waves. This topic includes material that is quite abstract if visualisation is not assisted. Wave material includes material that is quite complicated to explain if adequate learning resources do not support it. This was found when conducting observations in underdeveloped areas. From the observations, it was found that almost all students considered physics material difficult and not easy to understand. Some students answered that their lessons were sometimes challenging and sometimes easy, depending on the context of the subject matter being taught. From the observations, it was found that some of the materials considered difficult were modern physics, electricity, and waves. To anticipate this, the mobile thinking design prioritised it by integrating with the scientific literacy process so that the lessons presented are not only in rote form but offer different approaches, such as learning videos and quizzes, to make it easier for students to use. Figure 2 below shows what happened after developing learning materials for physics based on design thinking.

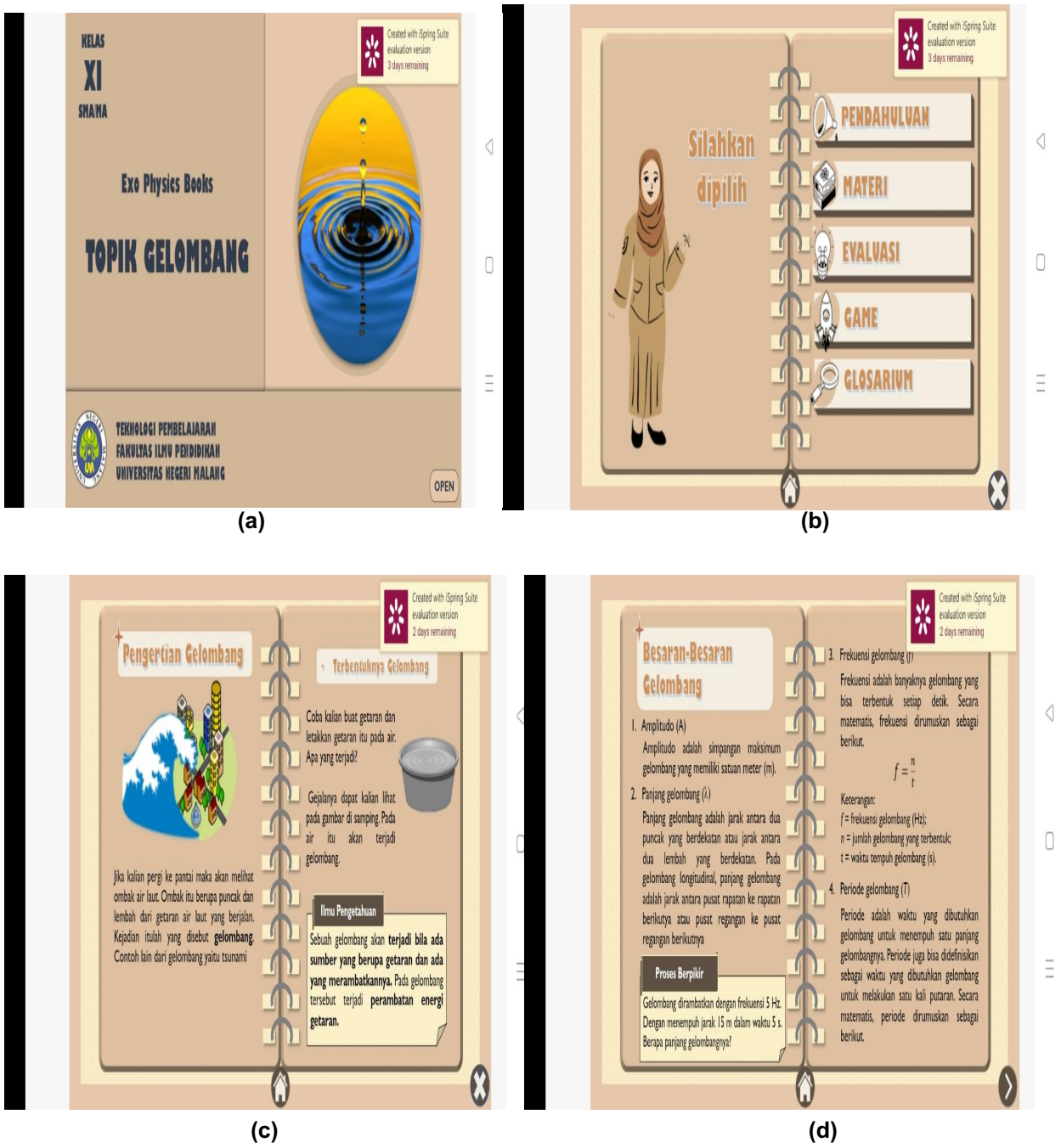

Figure 2: (a) front page, (b) material page, (c) material page, (d) advanced material, (e) display of wave equation material, (f) display of learning videos, pictures and simulations, (g) display of experiments, (h) games in the form of quizzes

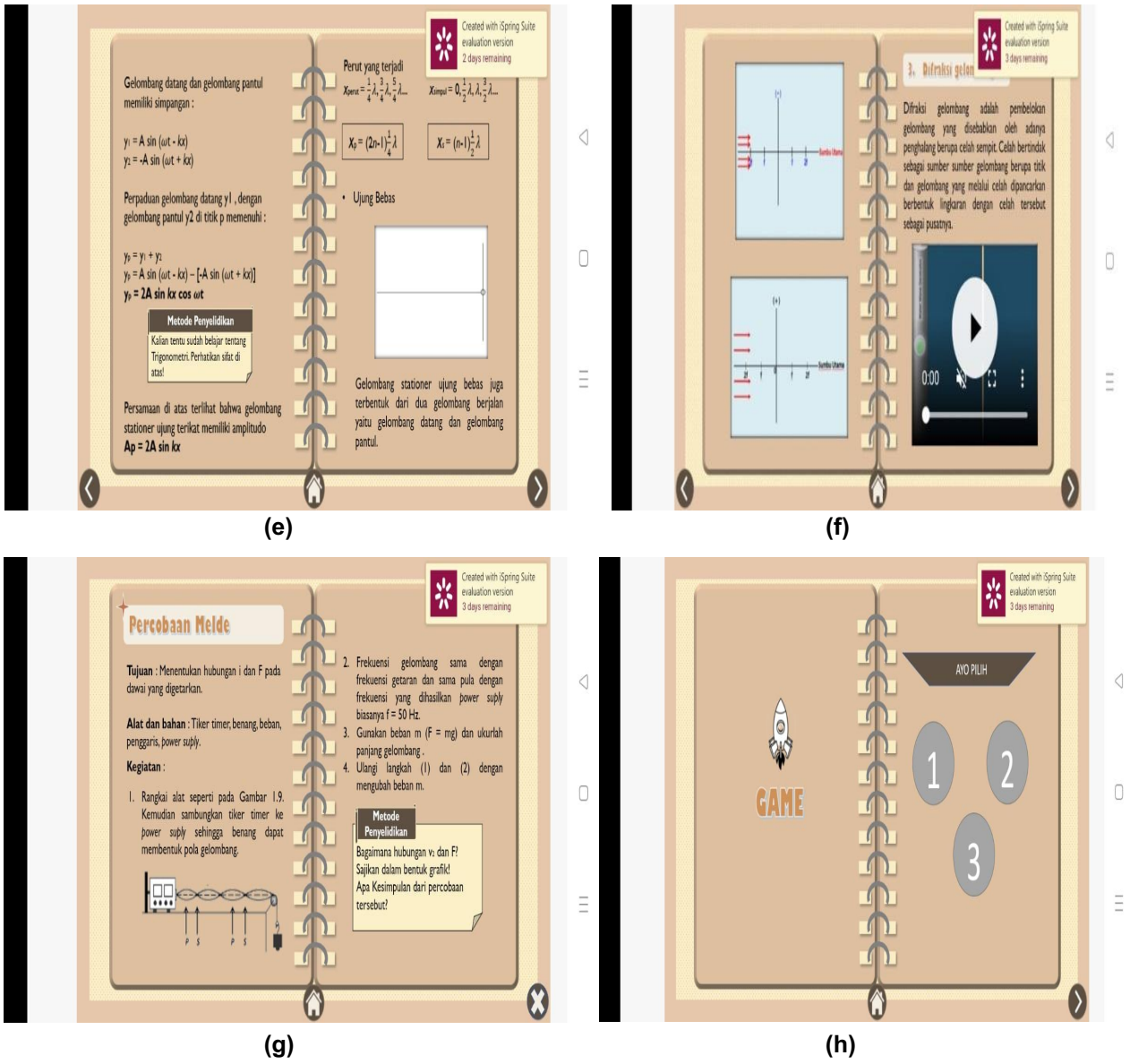

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Figure 2 shows that instructional media development is based on the specifications of the needs of the students according to the needs of the defined phases. According to the results of this analysis, students need learning media, which include material, experiments, simulations, learning videos, and games in the form of quizzes. Exophysics books are written with a needs-based approach, so students can learn anywhere and anytime. However, this differs from other mobile applications in that exophysics books are based on aspects of scientific literacy in the development process. The aspect of

scientific literacy included in the Exophysics book, namely science as knowledge, is presented as a definition, for example, in Figure 2c.

Furthermore, science as a process of thinking is presented in Figure 2d, while Figure 2g presents science as a process of inquiry. From the point of view of scientific literacy, which is the interaction between society and technology, it can be seen as a basic understanding of how waves work and how they can be used in everyday life. The link below will take you to the exophysics books application:

> https://exophysicsbooks.blogspot.com/2012/11/media-pembelahan-berbasis-android.html or by sending an email to suritno.fayanto.2201219@students.um.ac.id

The expected learning experience from using this application is that students who live in remote areas can get a proper education with a touch of technology, so there are new nuances in the learning process. The presence of technology can provide a sense of the learning process, which can inspire students to pursue their interest in learning further. Exophysics books can be designed with the principle of learning anywhere and at any time, allowing students to learn without sitting on a bench in a classroom. In addition, from the observations made in remote areas, 50% of students already have mobile phones or smartphones but they are only used for offline games or selfies. However, if students are appropriately managed, learning becomes a possibility. Besides that, exophysics books support 21st-century learning, especially in TPACK, so education equity in remote areas of Indonesia could be achieved according to the expected goals.

To produce an exophysics book that can be appropriately used, the development team is trying to test it on several teachers in several different districts in Indonesia. Development is being tried in five districts in Southeast Sulawesi, where access to schools still needs to be improved because of geographic limitations. On this occasion, the development team tries to see how the teacher responds when using the Exophysics book as a learning resource.

Based on Figure 3, it was found that, based on the analysis of the teacher response questionnaire, which covered five districts that were quite remote, the exophysics book was interesting to use. Each teacher almost always chose point 4 on the Likert scale for each question indicator. This shows that the Exophysics book can be used as a learning resource in underdeveloped areas of Indonesia. If the statement indicators are summarised into interactive media sections, the respondents indicated they were happy, motivational, involved, and interested. The teacher responded positively regarding the Exophysics book. Some teachers suggested that the Exophysics book was not only appropriate for material on waves but could be used for almost any subject.

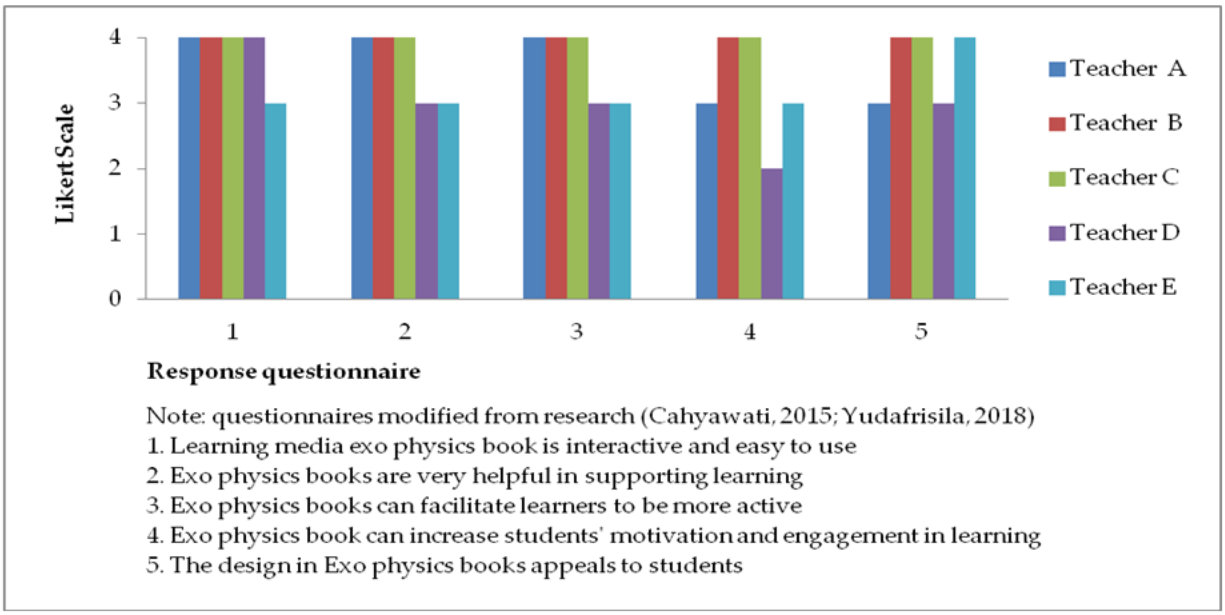

Figure 3: Teacher response graph

Figure 4 shows that, based on the analysis of the average Likert scale in the student response questionnaire, responses clustered at point 4, namely, strongly agree, and point 3, namely, agree. The student trials were held in five schools, all located in the same remote areas as the teacher trials. Three students were involved in the Exophysics book trial, each randomly selecting the same class and material topic, namely waves. Student responses were classified into cognitive, affective and consequential. From the analysis results (see Figure 3), the Exophysics book was dominated by affective and cognitive aspects but the difference was insignificant. There is only a one-point difference in the rating points for each aspect of this outcome. The Exophysics book on waves was designed with these three considerations in mind. This was done so that students would be focused on memorisation and involved with the material when these elements were presented, allowing them to be more confident and capable of reasoning. Of course, this is very useful and becomes the focus of attention when developing or designing a learning medium. Developers need to pay attention to these two things, so that they do not just focus on design but also on how their decisions affect students' cognitive and emotional skills. With the Exophysics book, it is hoped that it can be used to help make education a top priority in Indonesia's poor and remote areas. Several studies report that mobile-based learning has proven effective in learning physics, can be easily adapted to suit different needs, and can be used in any circumstances. Several important findings from the search results are: (1) the use of Android-based teaching materials in physics learning can be effective in training students' cognitive and effective abilities, for example, science process skills, and can motivate students to learn physics; (2) mobile devices can be useful for learning physics and can positively influence students' achievement and interest in learning physics; and (3) mobile learning can improve the way students

acquire knowledge and can encourage learning and participation in various physical spaces (Criollo-C.S. et al., 2021; Hakim et al., 2019; Nor & Hali, 2021; Nikolopoulou & Kousloglou, 2019).

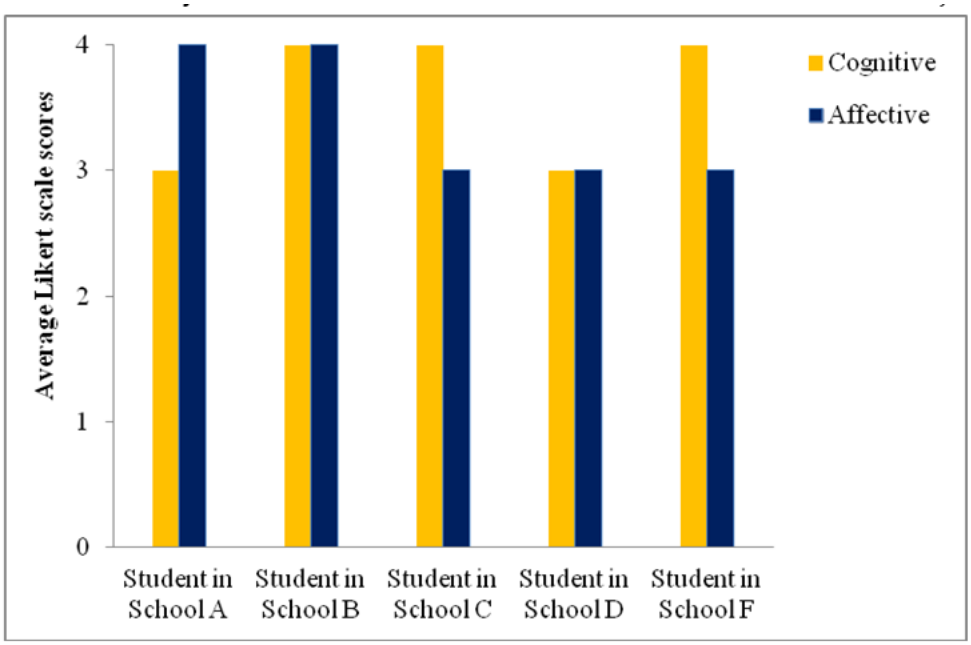

Figure 4: Student response graph

Furthermore, the Exophysics book on waves was designed to be as appealing as possible so that students will be interested in the learning resources they receive. Students are enthusiastic about learning when they can easily digest brief and straightforward material. Chang (2021) writes that an attractive instructional design can foster student interest in learning and generate student confidence when using digital learning media. An attractive learning media design is an integral part of developing an instructional learning design, which will undoubtedly be related to effectiveness in learning, especially as it concerns individual learners (Keller, 2010). Meanwhile, Sun & Hsieh (2018) reported that instructional media designed by considering the elements of student interest could increase students' intrinsic interest, making them more motivated to learn. Schneider et al. (2018) claim interesting media features could form perceptual linkages and increase learning motivation. This is, of course, as important as the information presented in Figure 2. In Figure 2, the exophysics book was designed to present material and learning videos that could be watched without being connected to the internet, display equations according to the context, and present games at the end of a session. This is undoubtedly quite different from other learning media products. Apart from prioritising the usability aspect, this also pays attention to the literacy aspect, which the government of Indonesia is currently reproducing.

In addition, from a teacher's point of view, the Exophysics book is attractive to teachers because the features are simple, reasonably elegant, and easy to use. In addition, several teachers mentioned that the existence of learning videos, experiments, and games in the form of quizzes made learning more enjoyable. One teacher expressed this: "The media being developed is very interesting, especially with

learning videos; so far, the learning media developed have only presented material, no videos, games, or experiments." This has a positive impact on the development of learning media resources. The Exophysics book presented in mobile form could make it easier for teachers to present material and increase their abilities to utilise ICT in learning. The same thing was conveyed by Criollo-C.S. et al. (2021) in their study: mobile learning will enable learning systems to take advantage of access, flexibility, and portability in learning, which will benefit teachers and students in the new digital era. Meanwhile, Khan et al. (2019) and Sharples et al. (2009) wrote that mobile learning enables the socialisation of education remotely, and promotes collaboration and communication among students, teachers, and teacher-students. Students and teachers could enhance learning through collaboration and help create a more personalised learning experience. Students and teachers could enhance learning through collaboration and help create a more personalised learning experience.

Conclusion

The design thinking method was used to make learning materials, and the results showed that the exophysics book on waves could help people in poor and remote areas to learn. This finding is supported by the results of limited trials related to the developed design, wherein a Likert-scale questionnaire was used, and the teachers' response was clustered at point 4 (strongly agreed), and student responses to each indicator were concentrated in the 3–4 range. In the student responses, the cognitive aspect was more dominant than the affective aspect in developing the Exophysics book. However, the difference between the two aspects is insignificant, because the difference in the range of scores is only one grade for each student in the five schools tested. In addition, the Exophysics book emphasised aspects of reasoning, according to concepts in scientific literacy studies, that could train students to reason and understand characteristics according to the studied topic.

The implications of developing mobile learning with design thinking are that learning resources are available, according to the needs of students, in remote and underdeveloped areas of Indonesia, even those with limited internet access. However, we should emphasise that this product is still being developed and tested, so it requires further study regarding extensive development, testing, and variables, especially effectiveness and practicality in using exophysics books in physics or science learning. The selection of materials will continue to be developed so that the subject matter, especially at the secondary school level, can be covered. Also, system, process and design improvements are necessary for product perfection.

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