Development of natural sciences e-modules based on android with a science, environment, technology, and society approach in the earth structure chapter

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The matter of the structure of the earth and its dynamics require sufficient visualization to imagine how the structure, layers of the earth, and things that can happen, such as earthquakes. Teachers have not used supportive media when delivering material on the structure of the earth and its dynamics, so students tend to have difficulty understanding the material. This study aims to produce a natural science e-module-based android with a science, environment, technology, and society (SETS) approach that is suitable for learning material on the structure of the earth and its dynamics. This research method uses a research and development (R & D) 4D model with four stages, namely defining, designing, developing, and distributing. The subjects of this study were 9 students of class VIII Islamic junior high school in Yogyakarta in the 2020/2021 academic year. The instruments used in this study were interview sheets and questionnaire sheets. Interview sheets are used to obtain information about data on media needs/learning resources needed by schools. While the validation sheet is used to determine the feasibility of the developed e-module. From the results of the validation analysis of material experts and media experts, the average score was 3.79 and 3.685, respectively. Meanwhile, from the results of the limited product trial, an average score of 3.84 was obtained. From the data analysis, it was concluded that the development of a natural science e-module-based android with the SETS approach on the material of the earth's structure and dynamics was suitable for use in learning. This E-Module can be used anywhere and trains students' independence in learning.

1. Introduction

The development of technology today is so fast. This is also accompanied by the development of media used in the learning process. In line with this, learning activities need to involve technology in packaging materials so that the implementation of learning becomes richer and learning outcomes are more optimal [1]. In this case, learning media is one of the important things that can be continuously developed to create an independent learning process [2]. When there is minimal use of media, it can lead to reduced engagement and interactivity, which may result in lower motivation levels and reduced focus on the learning material [3]. Moreover, if the learning content is not presented engagingly, it may not hold the attention of the students, and they may find it difficult to comprehend and retain the information [4]. On the other hand, the use of multimedia tools can enhance the learning experience by providing content representation, which can improve engagement and retention.

Learning media has several benefits including as a solution to the limitations of time, place, and senses in increasing students' interest and learning outcomes [5]. Media development must also continue to be developed to provide more optimal benefits in the learning process [6]. The learning process is still not independent, so the results obtained are not optimal [7]. The learning process in traditional classrooms often limits students' independence and creativity [8]. This can be caused by students who are used to relying on teachers to get information [9]. In addition, students are often expected to learn certain content in a fixed time and sometimes it is not aligned with their learning style. This can result in students feeling overwhelmed so that their learning outcomes are not optimal [10]. To overcome this problem, educators can combine several approaches to student-centered learning and active learning. This is to provide opportunities for students to engage in problem-solving independently and collaboratively. In addition, educators can incorporate digital media to support independent learning such as online platforms and adaptive learning systems [11]. By giving students more autonomy, educators can help improve student learning outcomes.

Efforts to optimize learning in the 4.0 revolution era require innovative, interactive, and efficient teaching materials so that they can improve students' independent learning [12]. Teaching materials are all learning tools used by teachers to deliver learning materials [13]. One of the teaching materials that can be used is a module. Modules are teaching materials that are systematically packaged and arranged to be studied independently [14]. Modules that are presented using electronic aids are termed electronic modules or e-modules [15]. Furthermore, the principle of an e-module is a form of learning material that is created systematically in an electronic format [16]. In the era of technological advances, e-modules can be loaded in an Android application that is easily accessible on smartphones [17].

The use of learning media with e-modules has the advantage of increasing student motivation, flexible use time, and training students' critical thinking skills. E-modules are learning resources that focus on certain topics and are packaged in web form so that they can be studied anywhere and anytime [18]. In addition, the e-module also contains video, audio, animation, and navigation [19]. The e-module is a source of independent learning to improve student competence and understanding. In addition, science learning will invite students to see natural phenomena and conclude according to students' abilities. The structure of the earth and its dynamics, the earthquake disaster is one of the natural science materials studied by Madrasah Tsanawiyah students, or Islamic-based junior high school.

To make it easier for students to understand the material, a SETS (science, environment, technology, and society) approach is needed [20]. The SETS approach was chosen in this study because it presents issues in society as early learning problems [21]. SETS-based science learning is effective in increasing disaster preparedness skills [22]. SETS is also seen as being able to improve students' critical thinking skills [23]. The SETS approach engages students in learning related to everyday life. Based on the problems above, it is necessary to develop an android-based science module with the SETS approach on the material of the structure and dynamics of the earth.

2. Literature review

2.1. Natural sciences module-based android

Technological developments are currently developing rapidly, so teachers must be able to develop adaptive teaching materials such as e-modules [24]. E-modules are teaching materials that are packaged systematically in electronic format containing animation, audio, and images [25]. E-modules are made using communicative and interactive language [26]. E-modules have several advantages such as being interactive in increasing students' understanding of concepts and learning can be carried out according to student learning styles [27]. E-Modules can be used as a means of independent learning for students because they can be accessed anytime and anywhere [28]. Thus, e-modules are electronic teaching materials that contain animation and video to train students learning independence because of their mobile nature.

E-module has self-instructional criteria, making students learn independently. Stand-alone, e-module does not depend on other media. Adaptive e-modules have adjustments to the development of science and technology. Whereas user-friendly, e-modules can be used in a friendly manner [29]. E-modules can be used in natural sciences, especially material on the structure of the earth and its dynamics. In terms of the structure of the earth and its dynamics, sufficient visualization is needed so that students can imagine the concept of the structure of the earth [30]. Meanwhile, Android is an operating system that runs on smartphones that are open source so that it can be used as a learning medium [31]. In addition, the use of Android-based e-modules makes it easier for students to use them anywhere and anytime [32]. Through Android, many programmers want to create learning applications. One of them is media that can be used in the learning process, namely android-based learning media [33].

2.2. SETS approach to Earth's structure and dynamics

Lots of learning approaches that can be applied in science learning. The learning approach used must be adapted to basic competencies and competency achievement indicators so that students can understand and apply them to learning in life [34]. One approach to learning science is SETS (science, environment, technology, society). SETS-based learning has five stages, including initiation, concept development, concept application, concept strengthening, and assessment. Learning using SETS has advantages including improving student communication, training students in scientific work, and helping students understand science [35]. Furthermore, SETS-based learning has advantages in improving students' science process skills [36]. SETS teaching focuses on how students can carry out investigations to gain interrelated knowledge about science, environment, technology, and society [37].

The characteristics of the SETS approach include students emphasizing the subject matter. Students are brought into situations to understand the benefits of scientific concepts that integrate technology for the benefit of society. Students are asked to think about various possible consequences in the process of transferring knowledge into form of technology. Students are asked to explain the relationship between the concepts learned and other elements in SETS [38]. One of the science materials studied by class VII junior high school students is structure of the earth and its abstract dynamics [39]. In this material, students need sufficient visualization to imagine how structures, layers of the earth, and earthquakes [40].

Knowledge and preparedness in dealing with earthquakes are needed to minimize the impact caused by earthquakes [41]. SETS is related to the structure of the earth's layers

which requires visualization in delivering material so that students can easily understand the concept [42]. The right approach to studying disaster material is the SETS approach. In the context of education, it brings the value that learning must go through a scientific approach (S-first) implemented in the form of technology (T) to meet the needs of society (second S). In addition, it is necessary to think about the various implications for the environment (E) [43]. From this learning it is hoped that students will get ideas that produce technology from the transformation of knowledge, considering environmental sustainability and paying attention to community needs.

3. Method

3.1. General background

The approach used in this study is a qualitative approach where at the beginning the researcher conducted a needs analysis by reviewing several articles and interviews to obtain data related to the needs of learning in schools and conducting a validation process by distributing validation questionnaires. Based on the analysis of the study of several articles made on learning as well as interviews conducted with science subject teachers, it was found that there was a need for learning media in the form of a natural science e-module-based android with the SETS approach. The type of research conducted is research and development (R & D) with a 4-D model consisting of define, design, develop, and disseminate stages [44]. However, the implementation of this research was carried out only up to the development stage. At the define stage, analysis activities are carried out including analysis of curriculum, students, concepts, and media with interviews of science teachers at MTs Al Ikhlas Berbah or Islamic-based junior high school. The design stage is carried out starting from design to e-module components based on things obtained from the previous analysis stage, namely making flowcharts, storyboards, and instruments in the form of expert validation questionnaires and student response questionnaires. Furthermore, at the development stage, validation, revision, and limited trials are carried out.

3.2. Participants

The population in this study is MTs Al-Ikhlas Berbah, Yogyakarta, Indonesia, or Islamic-based junior high school. The subjects of the study were students of class VII MTs Al-Ikhlas Berbah which consisted of 9 people. The sampling technique used in this study is purpose sampling where the sample has an average lifespan of 13 years [45]. The reason for selecting the sample and sampling technique is to find out the learning process in private Islamic-based private junior high schools. The validator in this study consisted of 2 lecturers who validated the feasibility of the e-module based on the material and media aspects. In other words, the sam-

ple size is relatively small, consisting of only nine students from one school, which may limit the generalizability of the findings to other settings. However, the use of a purposeful sampling technique can be appropriate in such cases, where the researcher aims to study a specific group of individuals with a unique set of characteristics or experiences [46].

By selecting participants who fit these criteria, the researcher can gain in-depth insights into the phenomena under investigation. Moreover, the use of two expert validators to assess the feasibility of the e-module can add to the study's rigor, as it provides an external perspective on the quality of the educational material [47]. However, it is worth noting that the validity of the study's findings may depend on the expertise and perspectives of the validators, and the assessment may be subjective to some extent. Overall, it is important to consider the context, sample size, and sampling technique when interpreting the results of a study, as these factors can influence the generalist and validity of the findings.

3.3. Instruments and procedures

The instruments used in this study were interview sheets, validation questionnaires, and limited trial questionnaires. The interview sheet consists of 7 aspects that are used to obtain information related to the identity of students, the use of learning resources, the application of SETS in learning, and the need for natural science e-module-based android in learning. The material expert validation sheet consists of 12 statement items that are used to get an assessment related to the material contained in the natural science e-module-based android with the SETS approach that has been developed. The media expert validation sheet consists of 15 statement items to get an assessment related to the media that has been developed. The limited trial questionnaire consists of 12 statement items from 4 aspects that are used to see the students' responses to the natural science e-module-based android with the SETS approach that has been developed. Collecting data in this study using questionnaires and documentation. an influence the generalizability and validity of the findings.

3.4. Data analysis technique

In the validation test questionnaire and the limited trial, the students' responses were assessed using a Likert scale (5). The values obtained from each aspect for expert validation

TABLE I. Assessment criteria for natural science e-module based android with the SETS model.

Score Range	Criteria
$3.2 < X \leq 4.0$	Very Feasible
$2.4 < X \leq 3.2$	Feasible
$1.6 < X \leq 2.4$	Moderate
$0.8 < X \leq 1.6$	Less Feasible
≤ 0.8	Very Less Feasible

FIGURE 1. The research stages.

TABLE II. The component of natural science e-module-based android with SETS approach.

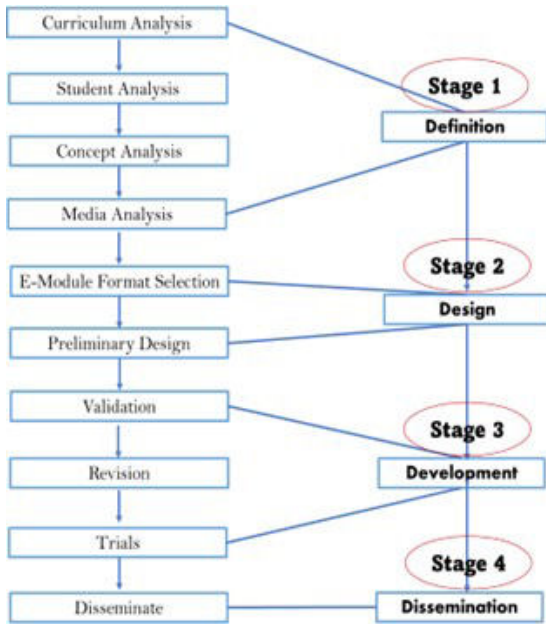| Introduction Section	Content Section	Ending Section
Cover	Concept Maps	Evaluation
	Core and Basic	
Foreword	Competencies	References
Instructions for Use	Materials	Glossary
SETS Approach	Learning Objectives	
Video	Introduction	
Menu	Development	
	Application	
	Stabilization	
	Summary	

instruments and limited trials are presented with the ideal average equation. After analyzing the data based on Eq. (1), the modules can be categorized as presented in Table I.

Table I is a natural science e-module-based android assessment criteria with the SETS approach that has been developed. The natural science e-module has been said to be very feasible if, from the validation analysis, it obtains a quantitative score range of $3.2 < X \leq 4.0$. The stages of this research can be summarized in a schema that can be presented as shown in Fig. 1.

4. Results

The results of this development research are in the form of a natural science e-module-based android with a SETS approach as a supporter in carrying out learning about the structure of the earth and its dynamics, specifically earthquakes. This natural science e-module-based android with the SETS approach was developed with a 4-D development model. The results of the application of the development model are as follows. The define stage, at this stage, consists of several stages including (1) an analysis of the 2013 revised curriculum and the concept of the earth structure and dynamics material with the basic competence (KD) being 3.10 Explaining the layers of the earth, volcanoes, earthquakes, and risk reduction actions before, during, and post-disaster according to the threat of disaster in the area; 4.10 Communicating efforts to reduce the risk and impact of natural disasters as well as self-rescue actions in the event of a disaster by the type of disaster threat in the area. The e-module developed in this study is focused on learning indicators 3.10.4 Explaining the characteristics of earthquakes and disaster risk reduction and 4.10.1 Practicing self-rescue actions in the event of a natural disaster. (2) analysis of students at Al Ikhlas Berbah aged between 12-14

years where at this age the level of curiosity and memory of students is high so that students can find out something and remember it, and (3) analysis of media that will be developed with adapted to the SETS approach. After obtaining an initial picture, the next step is to design learning media.

Design stage, at this stage the design of a natural science e-module-based android with the SETS approach is carried out with the Sigil application, Microsoft Word. The components of the natural science e-module with the SETS approach developed are presented in Table II.

Table II shows the design of components or parts of the science e-module that will be developed consisting of 3 major parts, namely the initial section consisting of five (5) subsections, the content section consisting of nine (9) subsections, and the final which consists of three (3) sub-sections. The development stage is the third stage in this development research. At this stage, the researcher developed an e-module based on the design of a natural science e-module-based android component with a SETS approach. Each component of the SETS approach which includes scientific, technological, societal, and environmental aspects is presented in the e-module. The developed e-module can be downloaded and installed first on the smartphone via the following google drive link https://bit.ly/e-modulsets. The results of the development of the natural sciences e-module can be seen in Fig. 2.

Figure 2 seems to be a display that presents a sub-theme related to the material of the structure of the earth and its dynamics. The sub-theme is divided into three main topics, which are the layers of the earth, earthquakes and their measuring instruments, and earthquake preparedness. The display also includes a list of menu options for the science e-module, which includes concept maps, KI/KD (core competencies/basic competencies), SETS, video, bibliography, and glossary. These options can provide students with a range of tools and resources to support their learning, including visual aids, core competencies and basic competencies, multimedia,
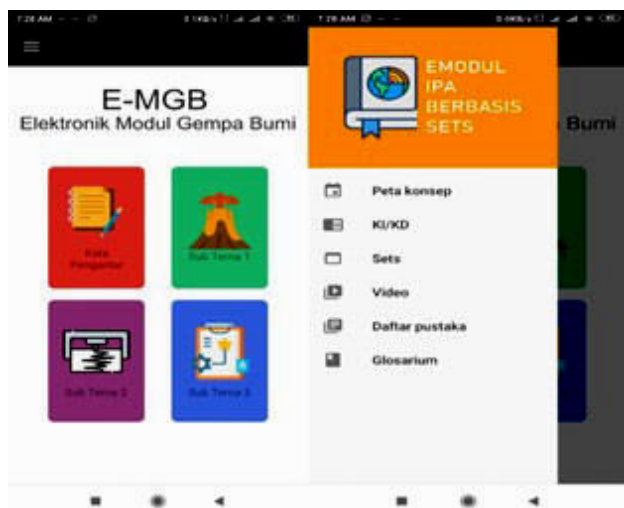
FIGURE 2. E-module display.

and references. Overall, this sub-theme display with its various menu options can help to organize and structure the material, making it more accessible and manageable for students. It can also provide students with a comprehensive overview of the material and the various resources available to support their learning.

Furthermore, the e-modules that have been developed are validated by experts, and limited trials are carried out. The results of the validation and testing are as follows: validation by material experts and media expert validation accompanied by several suggestions for further revision. Material expert validation and media expert validation were carried out by giving a questionnaire to eight (8) validators. Meanwhile, the results of this e-module validation based on the assessment of material experts can be shown in Table III.

The scores obtained from the four aspects of the material expert validation assessment obtained an average score of 3.79 with the interpretation of the e-module that has been developed very suitable for use in learning. Meanwhile, the results of media expert validation of the developed e-modules can be shown in Table IV.

The scores obtained from the five aspects of the media expert's validation assessment obtained an average score of 3.68 with the interpretation of the e-module that has been developed very suitable for use in learning. The next stage is a limited trial which aims to see how students respond to natu-

TABLE III. Material expert validation results.

Aspect	Value	Interpretation
Learning	3.8	Very Feasible
Contents	3.8	Very Feasible
Presentation	3.75	Very Feasible
Coverage of Materials		
and Exercises	3.8	Very Feasible
Average	3.79	Very Feasible

TABLE IV. Media expert validation results.

Aspect	Value	Interpretation
Design	3.625	Very Feasible
Visual Quality	3.8	Very Feasible
Contents	3.75	Very Feasible
Organization, Language,		
Readability	3.625	Very Feasible
Software	3.625	Very Feasible
Average	3.685	Very Feasible

TABLE V. Limited product trial results.

Aspect	Value	Interpretation
Perception of Ease of Use	3.88	Very Feasible
Recommended Benefits	3.88	Very Feasible
Product Attractiveness	3.75	Very Feasible
Actual Product Usage	3.88	Very Feasible
Average	3.84	Very Feasible

ral science e-module-based android with the SETS approach that has been made. This limited trial was conducted on 9 students of class VIII MTs Al Ikhlas Berbah. Meanwhile, the results of student responses to the developed e-module can be shown in Table V.

From the test results of the developed e-module product, it obtained an average score of 3.84 with a very feasible interpretation for use in learning.

5. Discussion

At the initial stage or definition, the researcher conducts an initial analysis consisting of the initial analysis, student analysis, and concept analysis. At this stage, several problems were found related to the use of teaching materials used were still in the form of a science book for the 2013 revised 2017 curriculum, the teaching methods used were lectures, question-and-answer experiments and assignments, and student conditions. These results are also consistent with research from several previous studies which found that many natural science textbooks and teaching materials are outdated or inadequate, which can lead to difficulties in understanding complex concepts [48]. In addition, many science educators still rely on traditional lecture-based teaching methods that are not attractive to students [49] Lecture-based teaching may not be effective for all students, as some students do better through hands-on activities or discussions.

Many students consider science subjects to be boring and difficult [50]. In many developing countries, there is a shortage of resources, such as textbooks, laboratory equipment, and technology, which can limit the quality of education students receive [51]. Teachers may lack the training and knowledge to teach science subjects effectively [52]. This is the

basic reference for researchers to develop teaching materials in the form of android-based science modules with the SETS approach so that students understand more about the environment and technology and can use it flexibly. At this design stage, the first is to design the storyboard, appearance, and content of the android-based IPA e-module using the SETS approach and product flowcharts. The design of the contents of this e-module has several sections, namely cover, introduction, menu, basic competencies, objectives, concept maps, SETS approach, materials, evaluation, and glossary. This e-module component was developed with the Sigil application where this application can be accessed offline using a smartphone.

At the development stage, the developed IPA e-module is validated by the validator to find out the deficiencies of the e-module. This research was conducted to develop an android-based science module with the SETS approach to the material on the structure and dynamics of the earth. This can be seen from the validation results of material experts and media experts in Tables 3 and 4 which are used to see feasibility and as a guide in revising the e-module. E-module validation is carried out by material and media expert validators. Material expert validation consists of 4 aspects of assessment, namely learning aspects, content completeness, presentation, material coverage, and exercises. The average value obtained from the validation of material experts is 3.79 with a very proper interpretation. This shows that in e-modules by the curriculum, there are already media components that help to learn, there are practice questions, and the presentation of the material is brief and systematic [53]. The coherent delivery of material and the setting of the science e-module help strengthen theory and clarify concepts and suitability of material [54].

Meanwhile, media expert validation consists of 5 assessment aspects, namely design, visual quality, content, organization, language, readability, and software. The average score of the material expert validation is 3.84 with a very decent score interpretation. This e-module can be accessed offline after being installed on a smartphone and used anytime and anywhere. In addition, another advantage of offline e-modules is that they are easy to distribute and install on multiple devices [55]. Offline e-modules can also be more cost-effective because there are no ongoing costs associated with internet connectivity or cloud-based storage [56]. In addition, offline modules can provide a more secure and controlled learning environment, because content is stored locally on the device and can be managed by the teacher or school [57]. However, there are also some limitations to offline e-modules. For example, content updates may be more difficult to implement without internet access, and there are limited opportunities for collaboration between students and teachers [58]. Overall, the choice between offline and online e-modules will depend on local infrastructure, available resources, and the specific learning needs and preferences of students and teachers.

This shows the e-modules developed by established e-module development standards. After the revision is completed, a limited trial is continued to see students' responses to e-modul. Student responses to e-modules are seen from the ease of use, benefits, attractiveness, and the use of actual products. Of the four aspects of the assessment obtained an average score of students' response of 3.84 with a very feasible interpretation of use in science learning. Student. response obtained a score of 87% with good criteria [59]. Based on the research obtained, the development of Android-based Natural Sciences e-modules with the SETS approach to the structure and dynamics material of the earth is categorized as very suitable for use in science learning. However, students tend to respond positively to e-modules that are interesting, interactive, and contain various multimedia [60]. E-modules can also help increase students' motivation and interest in the subject matter, especially when content is presented in a way that is relevant to their daily lives and experiences [61]. The success of e-modules depends on how effectively the modules are integrated into the environmental context. Therefore, feedback from students and ongoing evaluation of the effectiveness of the module can ensure that the e-module continues to meet students' needs and expectations.

Android-based science e-module with the SETS approach helps students to study independently anywhere and helps students understand the material on the structure of the earth and dynamics. Previous research had different approaches and materials, so the scope of this study was more specific, namely the development of android-based e-modules with a SETS approach to the material on the structure and dynamics of the earth [62]. This e-module focuses on helping students understand the material on the structure of the earth and its dynamics. This e-module is equipped with pictures and videos and is related to students' daily lives. The e-module developed uses the SETS approach which presents problems in the community as initial problems in learning [63]. The issue used in this e-module is the issue of earthquakes that often occur in Indonesia, especially in the Yogyakarta area. After being used in learning, students understand more about how to be more alert to disasters that occur.

6.   Conclusion

Based on the findings of this study, it can be concluded that the android-based science e-model with the SETS model is suitable for use in learning science on the structure of the earth. The development of android-based e-modules with the SETS approach for learning the structure of the earth and its dynamics can make a significant contribution to science education. By incorporating the SETS approach, e-modules can make the material more relevant and relatable to students' daily lives, which can increase their motivation to learn and make learning more interesting. In addition, interactive features that can be included in e-modules, such as videos, simulations, and quizzes, can increase students' understanding

and retention of material. In addition, the use of Android-based e-modules can also provide flexibility for students to study at their own pace, anytime and anywhere. This can be especially beneficial for students who may have difficulty attending in-person classes or need additional support to reinforce their learning. Therefore, the development of android-based e-modules with the SETS approach for teaching the structure of the earth and its dynamics can be a valuable tool for science educators to improve teaching and student learning outcomes.

7. Recommendations

The findings of this study can be used as a reference for one of the android-based teaching materials to be applied in learning physics on earthquake material. This finding is also one of the results of the initial development that can be used as a reference by future researchers in developing more effective learning products and technological developments. Through the development of this e-module, it is hoped that natural science or physics teachers in areas that are new to technology literacy can develop similar or better learning products.

8. Limitations

This research still has many limitations that can be improved by researchers or other practitioners who are concerned with developing natural science or physics learning media. The product developed in this study is still an e-module that can be developed in further research into augmented reality or virtual reality-based learning media. In addition, this study also has not tried to experiment or test the effectiveness of this e-module on student learning outcomes. This can be used as a follow-up to improve this research in the future.

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