23 (1), 2022, 34-11
Jurnal Pendidikan MIPA
e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Development of E-Modules to Improve Scientific Explanation Skills in Science Learning for Junior High School Students

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Abstract: Scientific explanation skill is one of the essential skills for students in science learning today. Scientific explanation is a reasoning skill that relates claims, evidence, and reasoning. Students can understand, articulate, and explain scientific phenomena accompanied by evidence and reasoning with scientific explanation skills. However, in reality, students are still lacking in scientific explanation skills. In an effort to improve scientific explanation skills, teaching material is needed to be developed in the form of e-modules. The use of e-modules in learning is expected to train students' thinking skills, one of which is scientific explanation skills. This study aims to determine the validity, practicality, and effectiveness of e-modules to improve the scientific explanation skills of junior high school students in science learning. The development of the e-module is carried out in three stages, namely preliminary research, prototyping stage, and assessment phase. The results showed that e-modules were included in the valid, practical, and effective categories. Thus, the e-module can be used and applied to develop science learning outcomes and scientific explanation skills.

Keywords: scientific explanation skill, e-module, science learning.

Abstrak: *Scientific explanation skill merupakan salah satu keterampilan yang penting bagi siswa dalam pembelajaran sains saat ini. Scientific explanation merupakan keterampilan bernalar yang mengkaitkan antara klaim, bukti, dan penalaran. Dengan scientific explanation skills, siswa dapat memahami, mengartikulasi, dan menjelaskan fenomena ilmiah disertai dengan bukti dan penalaran. Namun pada kenyataannya siswa masih kurang dalam kemampuan scientific explanation skill. Sebagai upaya meningkatkan scientific explanation skill siswa dibutuhkan suatu bahan ajar untuk dikembangkan yaitu berupa e-modul. Penggunaan e-modul dalam pembelajaran diharapkan dapat melatihkan kemampuan dan keterampilan siswa, salah satunya scientific explanation skill. Penelitian ini bertujuan untuk mengetahui kevalidan, kepraktisan, dan keefektifan dari e-modul untuk meningkatkan scientific explanation skill siswa SMP pada pembelajaran IPA materi sistem peredaran darah manusia. Pengembangan e modul dilakukan melalui tiga tahapan, yaitu preliminary research, prototyping stage, dan assessment phase. Hasil penelitian menunjukkan bahwasannya e-modul yang dikembangkan termasuk dalam kategori valid, praktis dan efektif. Dengan demikian, e-modul yang dikembangkan dapat digunakan dan diterapkan dalam pembelajaran IPA untuk mengembangkan hasil belajar IPA dan kemampuan scientific explanation skill.*

Kata kunci: *scientific explanation skill, e-modul, pembelajaran IPA.*

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DOI: http://dx.doi.org/10.23960/jpmipa/v23i1.pp34-44
Received: 31 January 2022
Accepted: 22 February 2022
Published: 17 March 2022

▪ INTRODUCTION

Scientific explanation skill is the ability to generate claims that explain phenomena by relating scientific principles to existing evidence and justifying claims using appropriate evidence and scientific ideas (De Andrade, Freire, & Baptista, 2019; Sandoval & Reiser, 2004). Scientific explanation skills are explanations that refer to how or why a phenomenon occurs (Chin & Brown, 2000; Seah, 2015). McNeill et al. (2006) also explained that scientific explanation skills are explanations formed to explain natural phenomena or support individual opinions or beliefs. Scientific explanation skill includes three aspects, namely claims, evidence, and reasons (Brigandt, 2016; McNeill, Lizotte, & Krajcik, 2006; Wijayanto, Supeno, & Bektiarso, 2020).

Scientific explanation skills describe causal interactions and fundamental mechanisms (Islakhiyah, Sutopo, & Yuliati, 2018). Scientific explanation skills have several goals: helping students understand and articulate a phenomenon with evidence and persuading others to get the most substantial explanation of several ideas (McCain, 2015). Based on this goal, the teacher can assess the conceptual quality of descriptions by measuring the extent to which students can articulate causal claims in specific scientific topics and support these claims with appropriate data and scientific principles. The quality of an explanation can be seen by assessing the extent to which data and scientific principles support the claim are coherent and adequate (Wang, 2015).

Scientific explanation skills are essential for students in learning. The Program for International Student Assessment (PISA) emphasizes involving students in scientific practice (OECD, 2018). One of the main goals of science education is to prepare students to synthesize and evaluate scientific explanations. Scientific explanation skill, also known as reasoning ability, is one of the skills demanded in the 2013 curriculum. Regulation of the Minister of Education and Culture Number 21 of 2016 stated that students must demonstrate processing, reasoning, and presenting core competency skills. According to Wang (2015), building scientific explanation skills is also a stepping stone to developing other abilities, such as identifying and supporting scientific arguments or evaluating models based on scientific evidence and knowledge. In addition, according to McNeill & Krajcik (2008), scientific explanation skills can help students build scientific explanations about phenomena where they justify their claims using appropriate evidence and scientific principles. So with these benefits, scientific explanation skills become essential for students.

Although it is an important skill, some research results show that students' scientific explanation skills are still unsatisfactory. Students rarely use knowledge to explain natural phenomena so that they are only owned at a basic level and are less meaningful (Cheng and Brown, 2015; Islakhiyah, Sutopo, & Yuliati, 2018). Some students also tend only to describe what they observe rather than explain why and how phenomena occur (Sampson, Grooms, & Walker, 2011). Students often have difficulty articulating and defending their knowledge claims; they often have problems coordinating their claims and evidence (Parnafes, 2012; Zangori & Forbes, 2015). Students still have many challenges even in classroom settings where the scientific explanation is explicit. According to Kirana et al. (2015), the quality of scientific explanation skills can be influenced by students' understanding of scientific explanations or how to write those explanations.

Of course, students' low scientific explanation skills are caused by several things. Students are rarely trained to construct reasoning about science in learning, both in delivering material and practicing scientific explanation skills. In addition, students' low scientific explanation skills are because learning in the dominant class is still teacher-centered (Faria et al., 2014). Hence, students become passive in learning and cannot explore their abilities and skills (Prasetya, 2014). To overcome these problems, the government made improvements to the 2013 curriculum, where learning is no longer teacher-centered but student-centered. In the student-centered learning process, teaching material in e-module is needed to improve students' scientific explanation skills.

The module is designed to enable students to learn independently and assist students in practicing their abilities and skills in responding to phenomena in everyday life. As technology develops, modules can be presented with dynamic access via mobile phones. The preparation of e-modules prioritizes student independence in doing learning so that students can solve the problems they face independently; therefore, e-modules are called effective and efficient digital media (Fausih & Danang, 2015; Kurniawan & Kuswandi, 2021). The presentation electronically of e-modul allows students to learn while studying and outside of lessons. In addition, using e-modules in learning can be more effective in training students' abilities and skills, one of which is scientific explanation skills (Astalini et al., 2019). The module acts as a scaffolding that helps students construct scientific reasoning directly (Muliardi, Supeno, & Bektiarso, 2018; Tang, 2016). Students must be faced with natural science phenomena to make scientific explanations (Zangori, Forbes, & Schwarz, 2015). Science phenomena can be displayed contextually in the module to understand how the content of science is related to the application of science.

Several researchers have conducted previous research to investigate and develop scientific explanation skills. There is a close relationship between the quality of students' conceptual understanding and their ability to explain quality explanations (Chin & Osborne, 2010; McNeill, Lizotte, & Krajcik, 2006). McNeill & Krajcik (2008) are developed a learning model for a scientific reasoning by adapting Toulmin's argumentation model. Braaten & Windschitl (2010) also researched the description of scientific explanation skills in science learning. In addition, Pinontoan et al. (2021) have also proven in their research that there is a positive influence on the application of learning with the support of e-modules in online learning statistics on reasoning abilities. Based on the explanation of the background, the following are the research questions that the study seeks to answer :

1. How is the validity of e-modules to improve scientific explanation skills in science learning for junior high school students?
2. How is the practicality of e-modules to improve scientific explanation skills in science learning for junior high school students?
3. How is the effectiveness of e-modules to improve scientific explanation skills in science learning for junior high school students?

▪ METHOD

The type of research carried out is educational design research or development research. The research development model used is the Plomp model, which consists of three steps: preliminary research, prototype development (prototyping stage), and assessment phase (Plomp, 2013). In the initial research stage, the researcher conducts a literature study from previous studies and analyzes problems and needs in learning. Researchers design products, learning tools, instruments, and validations at the prototyping stage. The e-module is designed on the canva.com website premium version and the Flip PDF Professional app. At the assessment stage, the researcher conducted a product development trial of the e-module to measure the effectiveness and practicality of learning. The e-modul was used in learning for three meetings. When learning using e-modules, students bring their own smartphones in learning, then the e-modules will be shared to students in the form of links that are shared in chat groups. Students access the e-module by clicking on the e-module link that has been shared. Then students read the material in the e-module and do practice questions and reasoning exercises for each learning activity in the e-module. The research subjects at assessment phase is one class at SMP Negeri 7 Jember, namely class VIII E, which consisted of 29 students. This research was held from September to November 2021.

The instrument used to measure the validity of the e-module is a questionnaire in the form of an expert validation sheet. Aspects assessed include aspects of content, material, presentation, language, and graphics. The assessment technique in the questionnaire uses a Likert scale with a score range of 1-4, with information, a value of 4 is very valid, 3 is valid, 2 is less valid, and 1 is invalid. The score obtained from the validation sheet will be calculated the percentage and average of the three validators, there are one science education lecturer and two science teachers. The e-module is said to be valid if it gets a validity score > 70% (Akbar, 2013).

The instrument used to measure the practicality of the e-module is a questionnaire in the form of a learning implementation sheet. The aspects of assesment include the students' activity in introduction of teaching, main activities in using of e-module, and closing of teaching. Researchers are conduct science teaching using e-modules, then the three observers will assess the implementation of learning by filling out a learning implementation sheet. The assessment technique in the questionnaire uses a Likert scale with a score range 1-3. The criteria of practicality consist of score 3 is practical, 2 is less practical, and 1 is not practical. The value obtained from the learning implementation sheet will be calculated by the percentage and average of the three observers. The e-module is said to be useful if it gets a practical value of 61% (Andriyani, 2018).

The instrument used to measure the effectiveness of the e-module is a test in the form of pre-test and post-test to asses scientific explanation skills. The scientific explanation skill indicators are claim, evidence, and reason for a phenomenon. Pre-test and post-test results will be analyzed using n-gain. The effectiveness of the e-module is obtained by looking at the increase in scientific explanation skills from the pre-test and post-test results. If the n-gain result is < 0.30, the increase in pre-test and post-test is low. If the n-gain result is $0.30 \leq g < 0.70$, the increase is moderate, and if the n-gain result is ≥ 0.70, the growth is high category (Hake, 1998).

The science subject matter in the e-module is about the human circulatory system. The subject matter includes material that is difficult for students. The subject matter was chosen because the concepts studied are complex, abstract, and the scientific phenomena are difficult to observe directly (Taufiqoh, Raharjo, & Indana, 2012). In this topic, concrete ideas are taught by connecting structure and function.

▪ RESULT AND DISCUSSION

1. Preliminary Research

At this stage, the researcher analyzes the problems and needs experienced in learning, as an initial description of the research that will be carried out through literature studies from previous research. The data was also obtained through an interview with a science teacher at SMP Negeri 7 Jember. The interview was conducted to find out how the science learning process was carried out at SMP Negeri 7 Jember which included the media used, the application of technology in learning, etc. Based on the interviews, it is known that teachers have never implemented science e-modules, especially those that aim to improve students' scientific explanation skills. Teachers use teaching materials in worksheets, powerpoint materials, and learning videos sourced from YouTube.

2. Prototyping Stage

At this stage, the researcher develops learning tools, research instruments, and e-modul. The learning tools are arranged in form of a syllabus and lesson plans. The research instruments are create consist of a questionnaire validation sheet, a questionnaire on the implementation of learning, and questions for pre-test and post-test. The e-module are designed through an website, namely canva.com. Through this website, researchers created the appearance of the e-module starting from the cover, content, and practice questions about other e-module components. This e-module was developed to improve students' scientific explanation skills. This is indicated by the preparation of materials and practice questions that are adapted to scientific explanation skill indicators, there are claims, evidence, and reasoning shown in Figure 1. This e-module consists of 4 learning activities, where in each learning activity there are learning objectives, materials, practice questions, and practice reasoning.

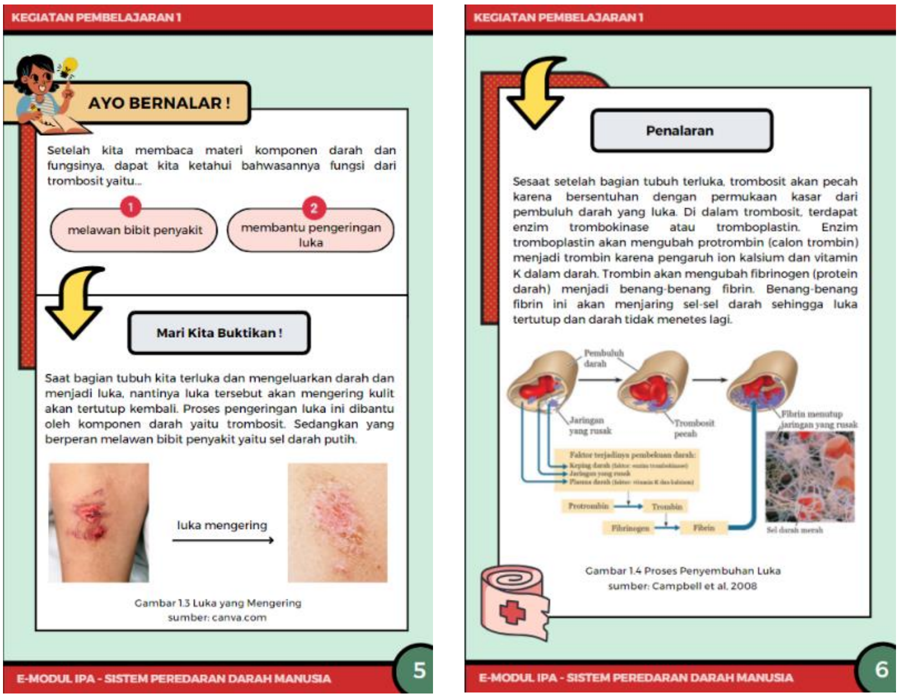

Figure 1. Fiture of scientific explanation indicators

The e-module could download from the canva.com website in pdf format. Then the pdf file will be uploaded to flip software professional PDF to be accessed online via a link as follow https://online.flipbuilder.com/emodulipa/vgji/. The editing process on Flip PDF Professional is shown in Figure 2. The appearance of the e-module after being uploaded to the professional flip pdf software is like a digital book display that can be flipped over while reading it. Students can access 3D effects and sound effects when open each page of the e-module such as shown in Figure 3.

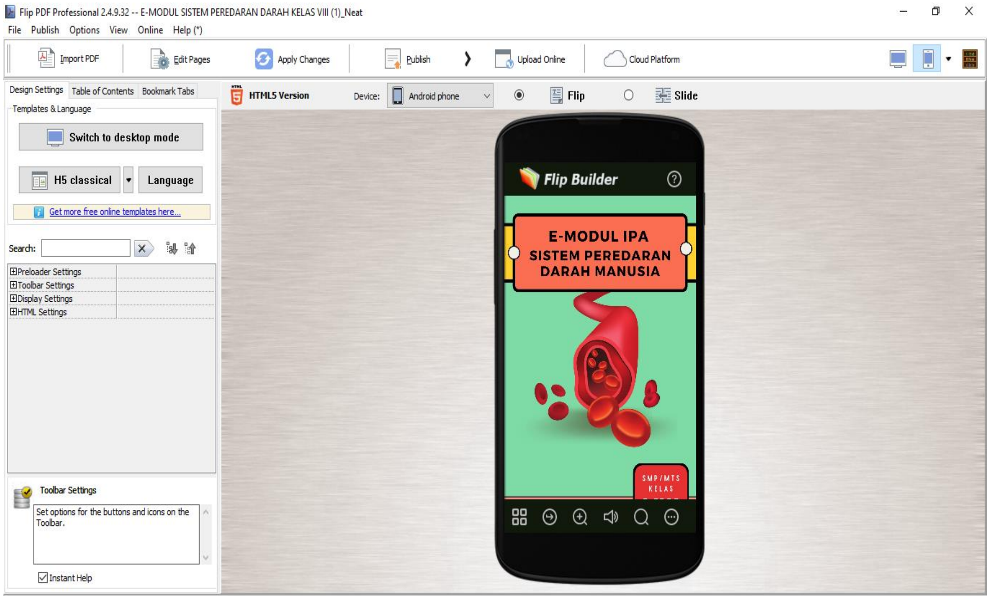

Figure 2. Uploading e-module on flip pdf professional

Fugure 3. The appearance of the e-module when accessed on a smartphone

Table 1. The Result of E-Module Validation

Rated aspect	**Validator 1**	**Validator 2**	**Validator 3**	**Average**
Content aspect	94%	94%	100%	96%
Material aspect	96%	92%	100%	96%
Presentation aspect	90%	95%	100%	95%
Language aspect	95%	95%	100%	97%
Graphical aspect	96%	100%	100%	99%
Average percentage				96%
Score criteria				Very valid

The results of the e-module validation can be seen in Table 1. It is known that the average validity score of the three validators is 96%. These results indicate the category is very valid and can be used without revision. This result in line with the opinion of Akbar (2013) that the e-module can be implemented in science teaching when validity score is above 70% - 100%. Based on the validation results, it can be seen that the e-module shows a valid category and can be used. The e-module has been well structured in content validity and construct validity. Nieveen (1999) stated that the product of development research feasible when the product adequate in the content and construct validity aspect. The content validity means that e-modul has needs and state of the art. The construct validity mean that all components of e-modul are arranged consistently and relate to each other. There are some suggestions from the validator that several writing and spelling of wrong words. This revised e-module will later be used in field trials to measure effectiveness and practicality.

3. Assessment Phase

The researcher conducts science teaching to evaluate effectiveness and practicality in learning at this stage. When learning was held, students had no difficulty accessing e-modules, but some students did not bring cellphones and did not have internet packages. These obstacles can be overcome by sharing cellphones with other friends to access e-modules. The results of evaluating the practicality of e-modules are shown in Table 2.

Table 2. The Result of E-Module Practicality

Observed aspects	**The lesson meeting**			**Average**	**Category**
	1	**2**	**3**		
Students' activity in the introduction of teaching	98%	100%	100%	97%	99%
Students' movement in the primary step of teaching	92%	94%	94%	94%	93%
Students' activity in the closing of teaching	100%	89%	100%	98%	96%
Average percentage				96%	
Score criteria				Very practical	

The practicality of the e-module is shown when the learning implementation process follows the learning implementation plan. The aspects observed in the learning process are students' movement when using the e-modul in every teaching step. Based on Table 2, it can be seen that the average practicality value of the three observers is 98% which is included in the convenient category. This is in line with Andriyani (2014) that the implementation of teaching when the practicality score is more than 61%. So with the practicality value of e-modules of 98%, it can be said that e-modules are very practical to be applied and used by students and teachers in science learning.

Table 3. The Result of E-Module Effectiveness

Data	Class VIII E	
	Pre-test	***Post-test***
Total student	29	29
Lowest score	26	62
Highest score	82	100
Average score	46,82	81.38
Deviation Standart	14.14	13.50
N-gain	0.65	
Criteria	Medium	

Based on Table 3, the results of the N-gain analysis are 0.65 and according to Hake (1998) this result is included in the medium category. So it can be said that there is an increase in students' scientific explanation skills by learning to use e-modules, with the intended increase being in the moderate category. That result aligns with Astalini et al. (2019) that using e-modules in learning can effectively train students' abilities and skills. Based on the results of the N-gain analysis, the developed e-module is quite effective in improving students' scientific explanation skills. According to Ratumanan & Laurent (2010), the learning process is effective if it follows the objectives and achieves the desired results. The most insufficient ability is the reasoning for why a phenomenon can occur. Students struggle when relating the logic in the e-module material with evidence or phenomena in everyday life.

The development research results show that the e-module is included in the valid, practical, and effective categories. E-modules can be used in science learning to improve the scientific explanation skills of junior high school students. This follows Nieveen's (1999) statement that product development can be successful when the resulting product meets the valid, practical, and effective criteria.

▪ CONCLUSION

The type of research is educational design research or development research. The research development model used is the Plomp model, which consists of three steps: preliminary study, prototype development (prototyping stage), and assessment phase. This research aims to determine the validity, practicality, and effectiveness of e-modules. Based on the study, it can be said that the e-module was feasible to facilitate student science teaching by access the link already shared. E-modul can be use to promote the scientific explanation skill in science teaching. E-modul includes the correct category with a validity score of 96%. The practicality of e-modules, when used in learning, fits in the efficient category. Furthermore, the effectiveness of e-modul getting an N-gain analysis result of 0.65 is included in the moderate category, which means that the students' scientific explanation skills have increased quite a bit. The result can be concluded that the e-module has valid, practical, and effective criteria.

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