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STEM Based Ecosystem Module: An Effort to Improve Students' Science Process Skill

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Abstrak

Penguasaan keterampilan proses sains siswa masih rendah, seperti tergambar pada beberapa penelitian yang disebabkan oleh penggunaan metode pembelajaran yang kurang tepat sehingga siswa kurang memahami keterampilan penerapan proses sains secara optimal. Oleh karena itu, pendidik perlu menggunakan pendekatan yang mampu melatih penguasaan keterampilan proses sains. Salah satu pendekatan yang menerapkan prinsip kerja ilmiah adalah pendekatan STEM. Integrasi pendekatan STEM dalam pembelajaran dapat mendukung penguasaan keterampilan proses sains. Penelitian ini bertujuan untuk mengembangkan modul berbasis STEM pada materi ekosistem guna meningkatkan keterampilan proses sains siswa. Metode penelitian pengembangan (R&D) dalam penelitian ini menggunakan model 4D. Uji validitas modul digunakan untuk mengevaluasi modul yang dikembangkan, yang diukur dengan menggunakan instrumen berupa angket validasi dari ahli media dan materi. Teknik analisis data menggunakan metode kuantitatif yaitu menghitung nilai persentase skala Likert. Modul sangat valid, menurut pengujian dua validator ahli, dengan persentase validitas berurutan 97% dan 98%. Hasil uji kepraktisan respon pendidik dan siswa masing-masing adalah 81% dan 93,71% yang menunjukkan modul sangat praktis. Analisis uji keefektifan modul diperoleh skor N-gain sebesar 0,76 dengan kriteria tinggi atau dikatakan keterampilan proses sains meningkat. Dengan demikian, modul ekosistem berbasis STEM yang dikembangkan valid, praktis dan efektif, serta memudahkan dalam memahami materi ekosistem, meningkatkan kepekaan dalam memecahkan masalah lingkungan dan menjadi upaya untuk meningkatkan keterampilan proses sains siswa.

Kata Kunci: *Modul, Pengembangan, STEM, Keterampilan Proses Sains*

Abstract

Students' mastery of science process skills is still low, as illustrated in several studies caused by the use of inappropriate learning methods so that students do not understand the skills of applying science processes optimally. Therefore, educators need to use an approach that is able to train the mastery of science process skills. One approach that applies scientific work principles is the STEM approach. The integration of the STEM approach in learning can support mastery of science process skills. This study aims to develop the STEM-based modules on ecosystem material in order to improve students' science process skills. The development research (R&D) method in this study uses 4D models. A module validity test is used to evaluate the developed module, which is measured using an instrument in the form of a validation questionnaire from media and material experts. Data analysis techniques use quantitative methods, namely calculating the percentage value of the Likert scale. The module is very valid, according to the testing of two expert validators, with sequential validity percentages of 97% and 98%. The results of the practicability test for educator and student responses are 81% and 93.71%, respectively, indicating that the module is very practical. The analysis of the effectiveness test of the module obtained an N-gain score of 0.76 with high criteria or it was said that science process skills increased. Thus, the developed STEM-based ecosystem module is valid, practical and effective, and makes it easy to understand ecosystem material, increases sensitivity to solving environmental problems and becomes an effort to improve students' science process skills.

Keywords: Modules, Development, STEM, Science Process Skill

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1. INTRODUCTION

Biology as a pure science is concerned with human life. Learning biology is basically not difficult, because studying biology means an effort to systematically discover natural facts and concepts (Harefa et al., 2022; Irhami, 2019). Biology contains four elements, one of which is a scientific process. The element of the scientific process in studying biology is the scientific method used to describe natural phenomena and produce scientific products. The science process will involve various skills, including science process skills (Sudarisman, 2015; Y. Suryaningsih & Aripin, 2020).

Science process skills are skills that help students access and find knowledge. Science process skills are classified into two types: basic science process skills and integrated science process skills. Basic science process skills include observing, classifying, measuring, using numbers, using space and time relationships, inferring, predicting, and communicating. Basic science process skills are required for the development of integrated science process skills (Kruea-In et al., 2015; Rauf et al., 2013). Identifying variables, graphing data, describing variable relationships, explaining data, formulating hypotheses, designing investigations, and concluding are all integrated science process skills. In biology, scientific process skills are related to scientific attitudes, which include attitudes toward observing, communicating, relating phenomena, and drawing conclusions from data (Gunawan, 2022; Hartati et al., 2022).

Nonetheless, students' mastery of science process skills is still low, as illustrated in several studies caused by the use of inappropriate learning methods so that students do not understand the skills of applying science processes optimally (Elvanisi et al., 2018; Mahmudah et al., 2019; Senisum, 2021). Even though the quality of an education can essentially be seen through the learning process (Erwinsyah, 2017; Tanjung, M. R., Asrizal., 2022). Therefore, educators need to use an approach that is able to train the mastery of science process skills. One approach that applies scientific work principles is the STEM approach. The STEM approach is used to ensure that students understand and are capable of applying four aspects of STEM to solve problems using knowledge (science), technology, engineering, and mathematics.

The use of STEM in education consists of several steps that begin with identifying problems that are relevant and related to students' real-world experiences. Students and their groups are asked to do research in their groups to solve the problem. Then each group member imagines a solution that will be carried out to solve the problem. Furthermore, they will plan and create products to be able to overcome these problems with trials, evaluations, redesigns and ends with product/prototype presentations. In STEM-based learning students will solve problems by making products or prototypes of a product by utilizing both knowledge (science), technology and techniques with calculations or mathematical concepts. Learners will naturally understand that their learning activities lead to STEM learning with problem solving goals (Cabuquin, 2022; Jolly, 2017).

The STEM approach to learning can bring out skills in students that play a role in improving human resources, for example the ability to solve problems and conduct investigations (Davidi et al., 2021; Rahmatina et al., 2020). In Indonesia learning with the STEM approach is still a new thing so that the facilities offered in STEM learning are also still limited. However, this is not a big barrier to implementing STEM. The STEM approach in learning can be integrated through media or teaching materials to help educators who have limitations in applying the STEM approach. As in the research put forward by previous study that the integration of the STEM approach can support the improvement of students' science process skills which are carried out through the use of the WhatsApp group application (Priyani & Nawawi, 2021; S. Suryaningsih & Ainun Nisa, 2021).

In addition to integration using applications, the STEM approach can also be included in teaching materials in the form of modules. Modules are teaching materials that are structured to create learning experiences and master student learning objectives specifically. Modules have different characteristics from other teaching materials, including (1) Self Instruction, modules can be used without relying on the media or other people, (2) Self Contained, namely only by using modules students can understand something the material as a whole, (3) Stand Alone, namely the module stands alone without reference to other media,

(4) Adaptive, namely it is hoped that the module can adapt to technological and scientific developments, and (5) User Friendly, namely modules that are friendly to its users (Gunawan, 2022; Nurlatifah et al., 2022).

Previously, the development of STEM-based modules was intended as the main teaching material or complementary teaching materials (Fauzi & Hayya, 2022; Meishanti, 2021; Sugianto et al., 2018). Whereas in biology learning the module was developed as an effort to increase scholastic literacy skills and stimulate HOST students (Afriyanti et al., 2021; Irmawati et al., 2021). So based on the previous research, the researchers re-developed STEM-based modules on ecosystem material. The researcher's goal is to develop STEM-based modules as an effort to improve students' science process skills and not just as a complement to the limitations of teaching materials. Ecosystem material was chosen because it is material related to human activities that have an impact on the environment. This is also a differentiator between current STEM-based module development research and previous STEM-based module development research. This study aims to develop the STEM-based modules on ecosystem material in order to improve students' science process skills.

2. METHODS

The development research (R&D) method in this study uses four D/4D models. The development research method is used when there is a product to be developed (Sugiyono, 2019; Thiagarajan, Sivasailam, 1974). The development implementation procedure is carried out in three stages (Nabila & Amir, 2022; Rochmad., 2012) as shown in Figure 1.

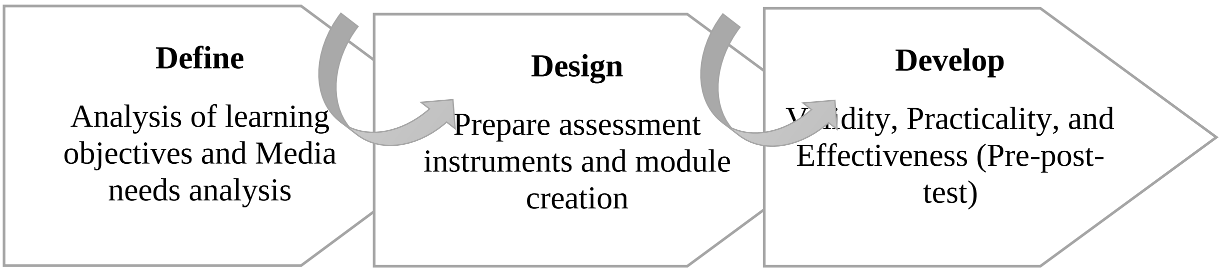

Figure 1. STEM-Based Module Development Stage

The researcher analyzes the information gathered about the extent of development required during the define stage. Several analyses were performed at this stage, including an analysis of learning objectives and an analysis of media development needs. The design stage during which the module product design is created, including the preparation of the front cover, contents, and back cover. The following stage is the development or revision of the initial module product based on the findings of the validity and effectiveness tests. The final step is to evaluate the module's effectiveness in order to improve students' mastery of scientific process skills.

The research subjects were 33 class X students and a biology teacher. These students will provide feedback regarding the practicality of using the module. In addition, they will complete the pretest and posttest to test the effectiveness of using the module in improving science process skills. Meanwhile, the teacher will provide feedback regarding the practicality of the module in ecosystem learning.

A module validity test is used to evaluate the developed module, which is measured using an instrument in the form of a validation questionnaire from media and material experts. Based on the responses of students and educators, assess the module's usability (Irawan & Hakim, 2021; Senisum, 2021; Yani et al., 2022). As well as an effectiveness test aimed at gaining an overview of how students' science process skills improved before and after using the module in learning. Tables 1, Table 2, and Table 3 describe the validation instrument lattice, as well as the practicality and effectiveness of the instruments.

Table 1. Validation Grid of Material Experts and Media Experts

Aspects	Media Expert Validation	Aspects	Material Expert Validation
Integration Aspect	Color combination Clarity of instructions	Integration Aspect	Compatibility with KD Clarity of learning objectives Clarity of learning flow Material suitability Clarity of material presented and related everyday life. The depth of the material presented Ease of understanding the material Accurate use of language
Aspects of Balance	Writing layout	Aspects of Learning Quality	Clarity of instructions in the use of the module The suitability of STEM-based learning (Science, Technology, Engineering, Mathematics) Image suitability Means of interaction between educators and students Independent learning
Letter Aspect	Font suitability Font size suitability Variation in font size and type Text/sentence readability		
Color Aspect	Background color match Text color match Image attractiveness		
Language Aspect	Language accuracy Sentence accuracy		

Table 2. Grid of Teacher Response Questionnaires and Student Responses

Aspects	Teacher Response	Aspects	Students Responses
Material Aspect	The modules presented are in accordance with the substance material Activities according to Basic Competency	Aspects of quality and learning objectives,	According to the instructions for use Clarity of discussion of the material Clarity of learning flow
Linguistic Aspect	The language used in the module already	Technical aspects	Clarity of color and appearance

Aspects	Teacher Response	Aspects	Students Responses
	effective and efficient		
Presentation Aspects	The sentences used are easy to understand learners The learning objectives achieved are clear Systematic order of presentation	Learning aspects	Text readability Feedback exercises Ease of use of the module Ease of learning Providing assistance in learning Explanation independently
Graphic Aspects	Use of fonts (type and size) Modules have proper layouts The module has an attractive cover design		
STEM-Based Aspects	Integrated with (Science, Technology, Engineering, Mathematics)		

Table 3. Pre-Test and Post-Test Grids

Basic Indicators Science Process Skills
Make Observations
Using the senses to collect various information about an object or incident
Predict
Foresee future events based on patterns of observation and knowledge previously
Communicating Effectively
Use your own words or graphic symbol to describe an action, object or event. Presents information obtained. Explain the results of information or data observations made.
Formulating Hypotheses
Can build tentative statements and can tested
Defining Patterns and Relationships
Classifies objects or events to within a certain criteria. Find similarities and differences object or event
Measure and Count
Measure and calculate the observation data Got
Conclude
Make "scientific conjectures" about an object or event based on data or information collected previously. Draw conclusions about the results from observation

Data analysis techniques use quantitative methods, namely calculating the percentage value of the Likert scale. The module is said to be valid if it has 60% validity criteria and is said to be practical if it has 70% practicality criteria (Akbar, 2013; Riduwan, 2016). The N-gain formula is used to calculate pretest and posttest results data to test the effectiveness of using the module on the mastery of science process skills. If $N\text{-}gain > 7$ it is said that the practicality of the module is high, if $0.3 \leq N - gain \leq 0.7$ it is said that the practicality of the module is medium, and if $N{-}gain$ is 0.3 it is said that the practicality of the module is said to be low (Mahuda et al., 2021).

3. RESULTS AND DISCUSSION

Result

Based on the input by the expert validator, development was carried out which then obtained the next input or revision, namely re-development of the description of the flow of student learning activities on the basis of the STEM approach. After the second stage of revision was carried out, it was concluded that the validity of the module was concluded by the two experts as shown in Table 4, and Table 5.

Table 4. Media Expert Validation

Validated Aspects	Total Score	Validity Level
Integration Aspect Aspects of Balance Letter Aspect Color Aspect Language Aspect	98%	Very Valid or can be used without revision

Table 5. Material Expert Validation

Validated Aspects	Total Score	Validity Level
Integration Aspect Aspects of Learning Quality	97%	Very Valid or can be used without revision

Data on the practicality of using the module was then analyzed through a response questionnaire from educators and students after the module was used in learning, practical data is shown in Table 6.

Table 6. Educator's Response

Practicality Aspect	Percentage	Category
Material Aspect	10%	Very Practical
Linguistic Aspect	12%	
Presentation Aspects	27%	
Graphic Aspects	15%	
STEM-Based Aspects	17%	
Total Score	81%	

The modules that are developed are mainly used by students so that the student's response to the use of the module becomes very important to produce practical modules. The number of students who became respondents to test the practicality of the developed module was 33 people. Each student then gives an assessor to the module as illustrated in Figure 2.

Base on Figure 2, the minimum score that students give is 52 and the maximum score given is 65. After obtaining the module practicality questionnaire score, the practicality percentage of the module is then calculated, which is then concluded in Table 7.

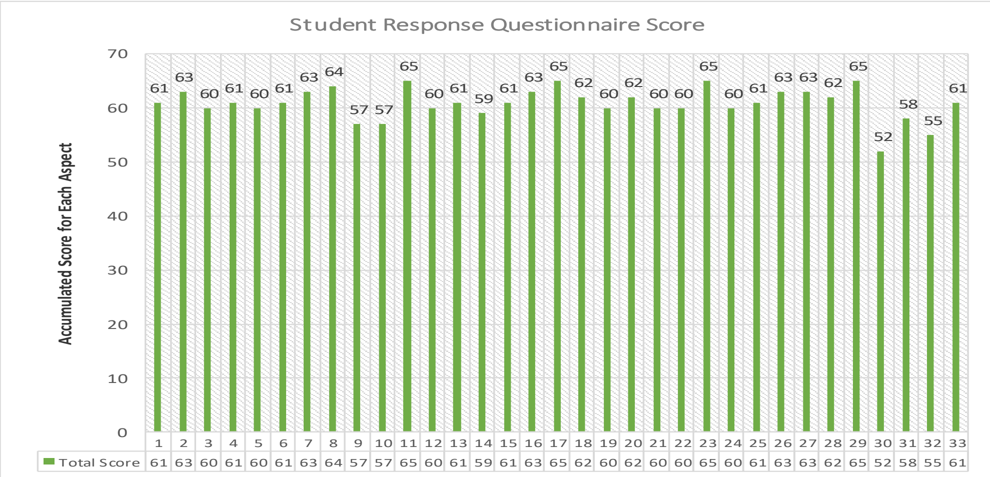

Figure 2. Student Response Questionnaire Score

Table 7. Student Responses

Number of Respondents	Percentage	Category
33 People	93.71%	Very Practical

Three aspects of practicality in the student response questionnaire are aspects of quality and learning objectives, technical aspects, and learning aspects. The percentage scores of the three aspects are then depicted in Figure 3.

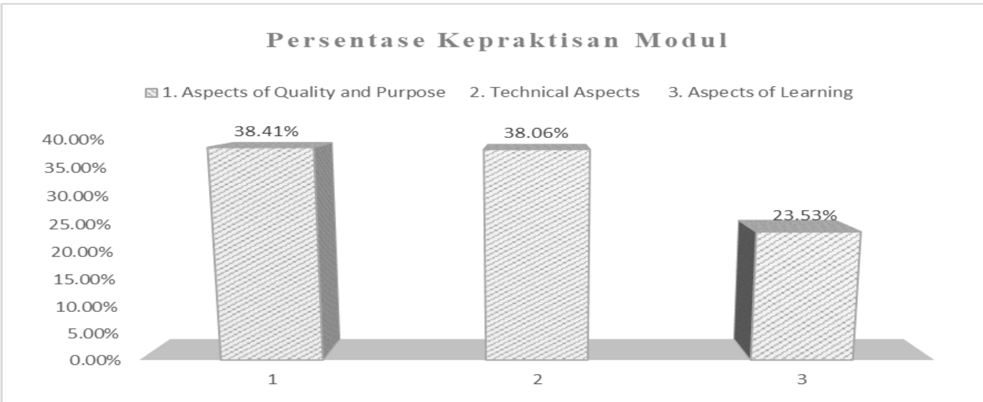

Figure 3. Module Practicality Percentage

Furthermore, the data in Figure 3 is analyzed so that the N-gain value is obtained as summarized in Table 8.

Table 8. Module Effectiveness Table

Science Process Skills Assessment	Average	N-gain	Criteria
Pretest	52.12	0.76	Tinggi
Posttest	88.33		

Discussions

Before the module is planned to be financed for product specifications to be developed, the module is then designed by applying the STEM approach to learning activities and the initial design is made as a basis for development before being validated by an expert validator (Al Azka et al., 2019; Sari et al., 2021). The module's quality can be determined through a validation process, in which the contents of the module are evaluated by a material expert, while media experts evaluate the module's design and appearance (Bunari. et al., 2021; Darmayasa et al., 2018; Lestari et al., 2019). Based on the final validation results as shows that the proportion of media expert validator scores is 97% or it can be concluded that the STEM-based ecosystem module is said to be very valid. In addition, media validator experts stated that STEM-based ecosystem modules were said to be very valid with a score proportion of 98%. Input containing information, suggestions and responses provided by validator experts for a product development is the goal of validation activities (Rahmawati et al., 2022; Safitri et al., 2019).

Validation is not only an activity of assessing module products but also as part of the purchasing process for the quality of the modules produced so that they are used effectively in the learning process (Puspita, 2019; Wardianti & Jayati, 2018; Ziliwu et al., 2022). The responses of educators and students show that STEM-based ecosystem modules are practically used in learning. Through the response questionnaire, it is known that the use of modules provides a flexible space for students in developing their knowledge. Students will build concepts of the material being studied by evaluating learning that has been carried out independently (C. Cruz & C. Rivera, 2022; Funa, A. A., 2021; Pramana et al., 2020).

The average test score in the initial test (pretest) was 52.12, and the average test score in the final test (posttest) was 88.33. The results of the two tests yield an N-gain value of 0.76 with high criteria based on data analysis. This illustrates that the module is said to be effective and can improve science process skills. Increasing the process of science skills is the basis for developing students' abilities to improve learning outcomes, understand nature and solve problems (Patresia et al., 2020; Utomo et al., 2020). STEM as an approach that is used as a basis for developing learning activities in modules becomes an embodiment process that can describe real learning concepts for students and improve the quality of learning. Besides that, it can direct students' interests and relate them to students' future career concepts (Farach et al., 2021; Özkul & Özden, 2020; Verawati et al., 2014). Science process skills are fundamental skills that students must acquire during the learning process in order to perform scientific work.

The developed STEM ecosystem-based module has proven to be effective in improving students' science process skills. It can be seen that using STEM-based ecosystem modules can increase students' sensitivity to problems in accordance with research (Nurhayati et al., 2021; Tanjung, M. R., Asrizal., 2022), however, it is different when students use STEM-based modules, students are not only sensitive or aware of a problem raised in learning but students try to solve it. If they haven't found the right solution, students can keep trying it. Experimental efforts carried out will continue to hone students' skills in carrying out scientific work which encourages the improvement of students' science process skills. Educators can play a role as a learning facilitator. The success of learning is supported by the ability of educators to understand the character of students by determining appropriate learning approaches and methods (Fitriani et al., 2021; Yamin & Syahrir., 2020).

The implications of module development are expected to be able to present learning activities that will apply the four STEM field approaches as outlined in the form of biology learning activities on ecosystem material, the learning process is expected to be able to optimize students' science process skills. In module development, educators become facilitators in the use of modules that will guide students in learning activities so that the level of students' science process skills increases.

The STEM-based modules developed by researchers are said to be valid, practical and effective, but still have limitations. Limitations in module development such as the development stage which is still in the develop stage and the number of respondents who are still in a small environment. This can be a recommendation to carry out further studies with more detailed development stages with a greater number of respondents in order to produce STEM-based modules that are generalized and are believed to be able to improve students' science process skills. Advanced STEM-based module development can aim to improve aspects other than science process skills or to improve specific learning competencies.

4. CONCLUSION

The developed STEM-based ecosystem modules are tested through validity tests, practicality tests and effectiveness tests. Based on the validity test of material and media experts it is known that the module developed is very valid. Then in the practicality test data is collected through the responses of educators and students using modules in learning. The outcomes of the practicality test based on the educator's response and the module students' responses are said to be very practical. Furthermore, an effectiveness test was conducted to determine the impact of using the module on improving students' science process skills that met high criteria, or it was stated that science process skills improved. As a result, the developed STEM-based ecosystem module is valid, practical, and effective for students to use in their learning.

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