



Development of the Diary Book of Science with the STEM Approach of Discovery in Improving Students' Concept Understanding and Scientific Communication Skills

Meila Fride Fikriana^{1*}, Wiyanto¹, Sri Haryani¹

¹Program Studi Pendidikan IPA Pascasarjana UNNES, Semarang, Indonesia.

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Corresponding Author:

Meila Fride Fikriana

meilafridefikriana@student.unnes.ac.id

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Abstract: This study aimed to obtain the product, feasibility and effectiveness of Diary Book of Science media with the STEM Approach Discovery syntax to improve Students' Concept Understanding and Scientific Communication Skills. The research and development method used in this study refers to the method developed by Borg & Gall. Data collection was carried out using questionnaires and tests. Diary Book of Science with the STEM Approach Discovery syntax was validated by three validators, namely material experts, media experts and linguists' experts, to determine the feasibility of the product itself. Students carry out further validation to find student responses and get suggestions for media development. Diary Book of Science with Discovery syntax with a STEM approach is intended to use Diary, which has a discovery learning syntax which is then combined with a Science, Technology, Engineering, and Mathematics (STEM) approach to the material of the earth's structure and its dynamics. With the study's results showing that it can improve the ability to understand concepts and scientific communication skills, the score of material experts is 89%, media experts are 85.67%, and language experts are 78.67%. The expert validation results for the Diary Book of Science with the Discovery syntax and STEM approach, material for the structure of the earth and its dynamics as a whole, has a percentage of 84.4%. This percentage is included in the very feasible criteria. Media Diary Book of Science with the Discovery syntax with the STEM approach is effectively used to analyze conceptual understanding and scientific communication skills with an increasing percentage of students who achieve learning mastery scores as indicated by differences in pretest and posttest scores.

Keywords: Communication; Concept understanding; Diary book of science; Discovery; Scientific; STEM

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results. The Law on the National Education System Number 20 of 2003 emphasizes that the purpose of education in Indonesia is to develop the potential of students to become human beings who believe in and fear God Almighty. Humans have noble characters, healthy, knowledgeable, capable, creative, and independent. Become citizens of a democratic and responsible. Education can free people

from poverty, ignorance and backwardness (Federova et al., 2023). Based on current field conditions, this goal contrasts the quality of education in Indonesia due to the Covid-19 pandemic.

The Covid-19 pandemic has caused school and tertiary education to experience adjustments in closing and changing learning methods from traditional to become online. The Federal Ministry in Nigeria ordered the closure of all schools and only reopened in October 2020. The Indian state declared the closure of schools and colleges in March 2020, and Indonesia is experiencing adjustments in learning and closing

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schools and colleges. Data from WHO (2021) per week in November 2021 stated that there were more than 3.1 million new cases globally. Until now, it has reached 249 million cases. The region in Southeast Asia reported more than 157,000 new cases and more than 3500 new deaths. The Covid-19 pandemic in Indonesia has impacted the implemented policies, namely Circular Letter 4 of 2021 concerning the Implementation of Limited Face-to-Face Learning for the 2021/2022 Academic Year. Learning with limited face-to-face time and using unsupportive media causes students to get less experience in class relevant to everyday life. According to research results by Purwanto et al. (2020), 70% of online learning does not work effectively, and the core competencies of teaching science still need to be fully instructed. This raises problems because teaching science requires more topic interpretation and detailed elaboration (Handayani et al., 2021).

The application of learning models that are unsuitable for online or hybrid science learning also influences students' understanding of the concepts of material received and students' scientific ways of communicating. The results of Nurbawani's (2021) research state that standard online learning processes, one of which is in the form of various learning methods and models, affect the quality of education. It must be supported and understood the constraints that occur during online learning so that it can run effectively (Backes et al., 2021). Differences in the application of learning models can affect the online learning process (Toharudin, 2020). A lack of understanding of the meaning of knowledge content, understanding, and the basis of interconnected parts of science can signify understanding concepts that need to be established. At the same time, communication is an essential component of schools for effective online learning. Online learning is the term that was first used when developing a web-based system as learning management system (LMS) (Singh & Thurman, 2019). With communication, the teaching and learning process can run. Based on the results of interviews regarding learning at junior high school Muhammadiyah 1 Cilacap, it was found that online learning requires adjustments in facilities and infrastructure. That can affect learning outcomes, and poor learning outcomes indicate low student interpretation of topics. Insight into a low-student concept topic has an impact on low scientific communication.

Learning outcomes at junior high school Muhammadiyah 1 Cilacap, especially in the material on the earth's structure and its dynamics, could be a better value in terms of the minimum completeness score, where 50% of the students still need to complete. According to Siswanto et al. (2021) scientific communication is a skill in communicating thought processes both orally and in writing. Written works,

such as practicum reports, scientific essays, journals, and so on, can be used for scientific communication; or oral communication, such as orations and scientific presentations (Majdi & Subali, 2018). Scientific communication consists of making tables or graphs, describing images, interpreting skills, and the ability to make conclusions (Nurlaelah et al., 2020). In addition, teachers should accommodate real experiences, for example, investigations or practicum, according to the problems presented (Sadiqin et al., 2017). The teacher allows students to interact with other parties, describe objects and events, ask questions, gain knowledge, and reconstruct natural phenomena.

On the problems faced by students with a lack of understanding of concepts and low scientific communication and teachers who are required to be more creative in delivering learning, learning models and strategies are needed to support independent learning in both online and hybrid learning. The concept of online learning is dynamic and can continue to change. Providing the best possible models, methods and learning materials to support implementation is crucial for successfully implementing distance/online learning (Rahmi, 2020). The discovery teaching model can direct students to obtain knowledge with their discoveries. There are advantages and disadvantages to practicing discovery learning models. The discovery learning model has several advantages, including students being able to actively participate in learning, encouraging an attitude of inquiry, providing a vehicle for connections between teachers and students, training students' cognitive abilities to discover and solve problems, and doing all of these things (Oktofika et al., 2019). Inquiry practice in discovery learning integrates the STEM approach (Dotimineli & Mawardi, 2021). In line with this, discovery learning can be integrated with the STEM approach. Learning with the STEM approach focuses on selecting techniques to solve problems while utilizing technology. STEM approach can make students think creatively, critically, communicatively, and collaboratively (Beswick & Fraser, 2019). The success of understanding the concept is influenced by the learning approach (Sagala et al., 2019). According to research from Pramesti et al. (2022), comparing the PJBL STEM learning model with discovery learning found that the discovery learning model has deficiencies in building creativity because there is no project in its syntax. The STEM approach will be perfect when combined with discovery learning in terms of problems in the field, both in terms of online and hybrid learning and problems of perception of scientific information and communication. Based on the results of existing studies regarding discovery learning combined with STEM, there were results where it was 93.83% effective in learning mathematics (Fri & Risfendra, 2021). Research from Hapizoh (2019) states that discovery learning with the

STEM approach can place junior high school students in science teaching outcomes that are superior to before. Research by Subakti et al. (2021) states that discovery learning using the STEM approach is effective in increasing creative thinking. Research by Fadlina et al. (2021) explains that discovery learning with the STEM approach can improve students' critical thinking, so that discovery learning combined with STEM can affect ongoing learning outcomes. In addition to the learning model used, learning media also play an essential role in implementing effective learning.

According to Saputra et al. (2021) media is prioritized to improve the quality of learning, especially in the process of understanding learning. The classroom media and technology teachers use are designed by themselves and can be adapted to the needs and learning characteristics. Media use in learning is prioritized to improve the quality of learning, especially in understanding learning and science process skills. In line with Hamidi et al. (2023) opinion, the media can involve various senses and organs during the learning process. The learning media used here is a diary book. Having a teacher's diary book can help students understand concepts by evaluating diary books. The diary book was developed in the framework of learning evaluation at each meeting. Its implementation can be taken home, even online or remotely or hybrid so that students can study independently and the teacher can determine the extent to which students understand concepts and scientific communication. Based on previous research, Diary-based learning media can be an alternative tool for teachers to check the progress of students' understanding (Susanti, 2021). According to Rhosyida et al. (2020), students can rewrite the material presented. Rewriting the material obtained today can be used to find out students' understanding of concepts but not with scientific communication. Therefore it needs to be developed again. The developed diary book was integrated with the discovery learning model with the STEM approach so that communication skills would also be known.

Method

This study uses research and development methods, known as Research and Development (RnD). The research and development method is a research method that is used to produce a particular product which is then tested for feasibility, effectiveness and user responsiveness to the media being developed. The research and development method used in this study refers to the method developed by Borg & Gall.

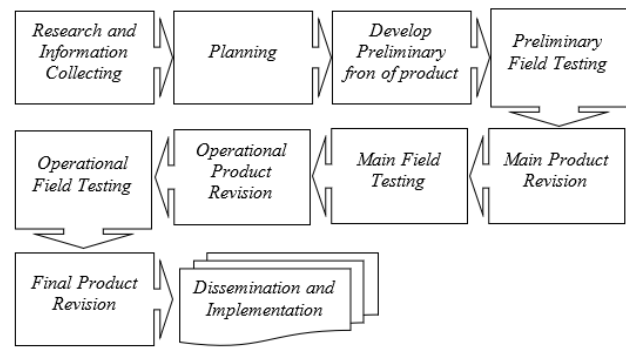


Figure 1. Steps for using the research and development Method (Borg & Gall, 1989)

The first stage is research and information collecting. This stage is carried out by studying literature and gathering information, identifying problems, and summarizing problems. School observations were carried out at this stage: junior high school Muhammadiyah 1 Cilacap. The results of the interviews directly stated that there were problems in learning science in class, especially regarding the earth's structure and its dynamics. Determination of the product is done after making observations. The product developed in this study is the Media Diary Book with the discovery learning model with the STEM approach. This media can add to student learning resources and reduce student boredom while studying. Combining the Diary Book and the Discovery learning model with the STEM approach helps understand the material so that students' learning outcomes can be the same as desired. The following planning stage is carried out by preparing learning designs for each competency with the method or learning of choice. The learning model determined is the Discovery learning model with the STEM approach. Furthermore, for this stage, an analysis of the material, core competencies and essential competencies are carried out, as well as gathering information that is useful in making study tools such as student and teacher response questionnaires, teaching tools, and validation sheets.

The third stage is to Develop a Preliminary Product. Products resulting from various research and development methods Educational productivity is expected to increase due to products developed through teaching research and development. Teaching methods, the competence of academic staff, modules, media, teaching materials, modules, and evaluation systems are examples of educational products. Products produced using research and development require a product design in the form of an image or chart to be used as a guide in making the product. The fourth stage is Preliminary Field Testing, the initial product of the diary book of science that has been developed and validated by a competent expert. In the validation stage, several parts are measured: aspects of presentation, language

content, and material content. Aspects of the material's content include the concept's depth and correctness. The language aspect includes the use of communicative language and is the same as the rules of Indonesian. Then the presentation aspect relates to whether or not the appearance of the developed diary book of science is attractive. The feasibility test uses the Diary book of Science feasibility assessment criteria with the STEM approach to discovery.

Table 1. The Diary Book of Science Feasibility Assessment Criteria with the STEM Approach to Discovery

Criteria	Percentage (%)
Very Eligible	81.25 < score ≤ 100
Eligible	62.505 < score ≤ 81.25
Decent Enough	43.75 < score ≤ 62.50
Less Eligible	25.00 < score ≤ 43.75

The developed diary book of science is feasible if it gets a score percentage of > 62.50%. If the percentage score is ≤ 62.50%, the diary book of science with the STEM approach developed must be revised.

The fifth stage is the Main Product Revision. A diary book of science that the validator has validated then the diary book of science is revised according to the suggestions given by the validator. Revision of the diary book of science is done to reduce the deficiencies in the book of science so that it can be used better. The sixth stage is Main Field Testing. This section applies pilot activities to students with a limited scale, namely as many as ten students. The trial was carried out by providing science product diaries on the material on the structure of the earth and its dynamics using the STEM and discovery learning approaches and providing questionnaires. This is to test student understanding. Scientific concepts and communication data from the trial results will be used to perfect the product being developed. The seventh stage of operational Product Revision. This stage is the revision or improvement stage after the initial trials are carried out at the main field testing stage. Products that have been tested using student response questionnaires are then corrected according to the suggestions given by students, which will then produce products that are ready to be tested on a large scale. The eighth stage of Operational Field Testing. At this stage, a large-scale trial was carried out by carrying out the learning process in the classroom using the revised product. The trial will be conducted in class VII SMP Muhammadiyah 1 Cilacap with 25 students. This trial aims to test the effectiveness of the discovery diary book of science with the STEM approach to the material structure of the earth and its dynamics in increasing understanding of scientific concepts and communication. The results of this trial were then analyzed using data analysis to determine the

effectiveness of the diary book of science with the STEM approach developed and to determine whether a revision was needed. The effectiveness of conceptual understanding and scientific communication in this study can be seen in the increase in pre-test and post-test results. This can be seen when the activity starts to finish according to the indicators on the question sheet. Then the average increase of students is analyzed by the Normalized gain formula (<g>).

Table 2. Criteria Value <g>

Value<g>	Criteria
(<g>)<0.3	Low
0.3 ≤ (<g>) ≤ 0.7	Moderate
(<g>)>0.7	Height

The Last Stage is the Final Product Revision. Product revision using reference from the results of the analysis of large-scale trials. At this stage, the product is revised to improve during development. The goal is to produce a science discovery diary with a STEM approach that is appropriate for use in Integrated Science learning on the material of the earth's structure and its dynamics.

Result and Discussion

The feasibility analysis of the Science Diary with the Discovery syntax and the STEM approach to the material of the earth's structure and dynamics can be seen from the validation of material experts and the validation of media experts. The Diary Book of Science validation test with the Discovery syntax has a STEM approach to the material structure of the earth, and its dynamics, including material and media validation. The media expert validation test is further divided into linguistic validation and presentation.

The validation test was carried out by one science material expert lecturer, one science media expert lecturer, one language expert lecturer, two science teachers, and two Indonesian language teachers. The results of the Diary Book of Science validation test with the Discovery syntax with the STEM approach are presented in Table 3.

The results of the research in table 3 show that the results of the assessment of the science material expert validators mainly obtained relatively high presentations from three experts. Suppose the scores of three science subject matter experts are averaged. In that case, a percentage score of 89% is obtained. The result means that the material on the structure of the earth and its dynamics in the Diary Book of Science with the Discovery syntax with the STEM approach is very feasible. The presentation validator representing media experts also shows the same thing: the average

percentage of the three experts is 85.67%, which means they are in the very decent category.

Table 3. Due Diligence Test Results by Experts

Validation	Percentage (%)	Criteria
Language	72	Eligible
	78	Eligible
	86	Very Eligible
Material	77	Eligible
	98	Very Eligible
	92	Very Eligible
Presentation	91	Very Eligible
	94	Very Eligible
	72	Eligible
Average	84.44	Very Eligible

Furthermore, media experts related to language in the Diary Book of Science, which was developed in this study, showed quite the same results. The average percentage score of the linguistic assessment is 78.67%, which is included in the feasible criteria. The expert validation results for the Science Diary Book with the Discovery syntax with the STEM approach, material for the structure of the earth and its dynamics as a whole, has a percentage of 84.4%, where this percentage is included in the very feasible criteria. These results indicate that the Diary Book of Science media with the Discovery syntax with the STEM approach, material on the structure of the earth and its dynamics, is feasible to be used as learning media in the classroom. The feasibility of the Diary Book of Science with the syntax of Discovery has a STEM approach. Material on the earth's structure and its dynamics is carried out constructively, with the opinions of different experts according to their fields of competence. The feasibility of the Diary Book of Science with the Discovery syntax is based on the STEM approach. Material on the earth's structure and its dynamics are assessed from 3 fields: language, media and materials.

The feasibility of the Diary Book of Science with Discovery's syntax of the STEM approach, material on the structure of the earth and its dynamics, was assessed by linguists by three experts, namely one expert from the Indonesian lecturer at IAIN Metro Lampung and two experts from the Indonesian teacher. The feasibility of the Diary Book of Science with a Discovery syntax with a STEM approach, material for the structure of the earth and its dynamics by the two experts aim to provide assessments, suggestions/input, and constructive criticism for the improvement of the Diary Book of Science with a Discovery syntax with a STEM approach from a linguistic point of view. Based on the linguistic aspect, the indicators that are assessed are compatibility with the level of intellectual and emotional development of students. Then it is also seen in the structure of sentences, standard terms, understanding of messages or information, and the ability to motivate students.

Another category assessed is the ability to create interactive, communicative, consistent interactions using terms and symbols. The feasibility test results from three experts showed that the Diary Book of Science's syntax of Discovery with the STEM approach to the material structure of the earth and its dynamics was declared feasible by two experts and very feasible by one expert. This happened because every expert gave a good assessment of the Science Diary Book with the Discovery syntax with the STEM approach to the material structure of the earth and its dynamics. In each assessment indicator, each expert gives a minimum rating on a scale of 3 to produce a good and proper assessment. The three experts stated that the Diary Book of Science has the syntax of Discovery with the STEM approach, material on the structure of the earth and its dynamics, which already uses scientific language and is by the level of development of students. The results of these findings are by Siagian's (2016) research that based on language feasibility, a book at least uses scientific language.

Analysis of the effectiveness of the Diary Book of Science with the Discovery syntax of the STEM approach to increasing conceptual understanding. The ability to understand students' concepts is known through acquiring pretest and posttest scores. The pretest was carried out to determine the initial ability of students in their ability to understand the concept. Then after learning was carried out using the Diary Book of Science learning media with the Discovery syntax with the STEM approach, the posttest was given to students at the end of the meeting to find out the students' final ability in understanding the concept. The average results of the pretest and posttest data of students' scientific communication skills are presented in Table 4

Table 4. Average Pretest and Posttest Values for Understanding Concepts

Number of students	Average	
	Pretest	Posttest
25	44.90	81.10

Based on the test of the ability to understand the concepts given to students, the Diary Book of Science media with the Discovery syntax with the STEM approach increases the posttest of the ability to understand the concept. The initial average of 44.9 increased to 81.1. The results of the pretest and posttest are then carried out by the N-Gain test. The N-Gain test was carried out to determine how much the students' concept understanding skills increased after experiencing learning treatment through the Diary Book of Science media with the Discovery syntax with the STEM approach. The N-Gain test is also intended to determine the effectiveness of using the developed

Diary Book of Science media. The following results of the N-Gain test are shown in Table 5.

Table 5. N-Gain Test Results of Students' Understanding of Concepts

	N	N-Gain	Criterion
Pretest and Posttest	25.00	0.60	Moderate

The results of the pretest-posttest N-Gain test showed that the increase in student's conceptual understanding abilities in this study was meant in the medium category. These results indicate that using the Diary Book of Science media with the Discovery syntax with the STEM approach effectively increases students' conceptual understanding abilities. This is by previous research that the application of the STEM-based Discovery Learning model can improve student learning outcomes, especially in understanding the concept (Fadlina et al., 2021).

This effective result can occur because learning that applies the Diary Book of Science media with the Discovery syntax with the STEM approach encourages students to be serious in remembering, understanding, and applying it. Reading, writing, observing and working on projects can be used to solve problems (Pramesti et al., 2022). Writing activities can use to verify students' understanding of concepts (Setiawan et al., 2019). According to research by Sit et al. (2020), those who influence the understanding of concepts are educators, learning models, facilities, and infrastructure. According to Dewi et al. (2019), in understanding the concept of students, educators should use a learning model that emphasizes constructing knowledge. The Diary Book of Science with the Discovery syntax with the STEM approach provides opportunities for students to understand concepts coherently and systematically in building knowledge. Each individual will build meaning for the information obtained (Bada, 2015). Increasing the independence of students to build and construct meaning influences their understanding of concepts (Fahyuni et al., 2019). The use of the Diary book will increase motivation psychologically so students can improve information processing (Getie, 2020). Improved information processing will have a positive impact on conceptual understanding. One of the functions of learning media is to accelerate the learning process and help students understand learning (Winarni et al., 2020). Recording the learning journey through the Diary Book will dynamically increase understanding both sooner and later (Nind et al., 2020). The Diary Book of Science with the Discovery syntax with a STEM approach is focused on learning the structure of the earth and its dynamics so that it focuses on a material that will make it easier to get solutions which will then affect understanding of concepts.

Analysis of the Effectiveness of the Diary Book of Science with the STEM Approach Discovery Syntax was conducted to see the improvement of Scientific Communication. Students' scientific communication skills are known through the acquisition of pretest and posttest scores. The pretest was conducted to determine students' initial abilities in their scientific communication skills. Then after implementing the Diary Book of Science learning media with the Discovery syntax with the STEM approach, the posttest was given to students at the end of the meeting to find out the students' final abilities. The average results of the pretest-posttest data on students' scientific communication abilities are presented in Table 6.

Table 6. Average Pretest and Posttest Scores in Scientific Communication

Number of students	Average	
	Pretest	Posttest
25	29.00	82.30

Based on the scientific communication ability test given to students, the Diary Book of Science media with the Discovery syntax with the STEM approach increases scientific communication posttest. The average, initially only 29, increased to 82.3, and then the N-Gain test was carried out. The N-Gain test was carried out to determine how much students' scientific communication skills increased after experiencing learning treatment through the Diary Book of Science media with the Discovery syntax with the STEM approach. The N-Gain test is also intended to determine the effectiveness of using the developed Diary Book of Science media. The following results of the N-Gain test are shown in Table 7.

Table 7. Student Scientific Communication N-Gain Test Results

	N	N-Gain	Criterion
Pretest and Posttest	25	0.743	High

The results of the pretest-posttest N-Gain test showed that the increase in students' scientific communication skills in this study was included in the high category. These results indicate that using the Diary Book of Science media with the Discovery syntax with the STEM approach effectively improves students' scientific communication abilities.

These results indicate a significant increase in students' scientific communication skills. This statement is in line with research by Subakti et al. (2021) stated that discovery learning using the STEM approach improves students' critical and mathematical thinking. There is a relationship between creative thinking and scientific process skills (Yildiz & Guler Yildiz, 2021). STEM can improve communication by using

representations to present scientific ideas (Owens & Hite, 2020). This statement is reinforced by other research, which shows that learning that utilizes STEM game projects can improve students' scientific communication. Other studies further explained that using a Diary Book can make students feel free to express their feelings and thoughts (Rhosyida et al., 2020). This finding explains that using the Diary Book eliminates the pressure or fear students usually feel when they want to convey the results of their thoughts. This loss of pressure to express opinions makes students free to write down the knowledge or information they have obtained so that indirectly students have communicated their knowledge through the Diary Book of Science with the Discovery syntax with the STEM approach.

This shows that using the diary book of Science with the Discovery syntax with the STEM approach can make students more active in expressing their opinions in the teaching and learning process. The addition of learning variations in the form of a Diary Book of Science with the syntax Discovery with the STEM approach focuses on the activeness of expressing students' opinions towards active scientific communication. This is due to the STEM approach to the discovery syntax, which trains students to carry out scientific learning activities. This statement is reinforced by previous research that Discovery learning with puzzle media can improve students' scientific communication skills. Learning becomes more fun and exciting when students are trained to move, communicate and think. The Diary Book of Science with the Discovery syntax with the STEM approach allows students to represent many data to build skills in scientific communication.

Conclusion

Based on the results of "the development of the Diary Book of Science with the STEM approach to Discovery to improve students' scientific understanding and communication skills". It can be concluded as follows: The Media Diary Book of Science, with the Discovery syntax of the STEM approach to the material of the earth's structure and dynamics, has been declared very feasible to be applied in learning by media experts and material experts. Media Diary Book of Science with Discovery syntax with a STEM approach to the material on the earth's structure and its dynamics is effective for increasing students' conceptual understanding skills. Media Diary Book of Science with the Discovery syntax with the STEM approach to the material on the earth's structure and its dynamics effectively improves students' scientific communication skills with N-Gain in the high criteria.

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