

Development of a STEM-Project Model to Enhancing Science Process Skills High School Physics Subject

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Abstract: The background to this research is the low level of science process skills due to a lack of them students are accustomed to carrying out experimental or practical activities in physics learning in previous classes or levels. The aim of this research is to develop a STEM-Project model to determine the level of understanding of science process skills in high school physics subjects that is feasible, effective and practical. This research is development research (Research and Development) using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The research instruments used were validation sheets, interviews and questionnaires. Product trials were carried out at SMA Negeri 1 Piyungan in class XI for the 2023/2024 academic year. The results of the research can be concluded: (1) The average results of the feasibility test assessment of material aspects have a validity of 91% with a very valid category with (very good) and the LKPD aspect with a validity of 93% is very valid (2) The average results of the module readability assessment are 80.67% in the very well read category. (3) The average result of student response assessment to the module is 80% in the very good category. (4) The average result of teacher response assessment to the module is 93% in the very good category. This means that the Project-STEM model can have a significant and effective effect on improving understanding of science process skills in physics subjects at SMA Negeri 1 Piyungan.

Keywords: Physics subjects, Project-STEM Models, Science Process Skills.

Introduction

The world of education is very important in developing and prospering Indonesia. Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have spiritual, religious strength, self-control, personality, intelligence, noble morals, and the skills needed by themselves, society, nation and state.

Education aims to enhancing the quality of students. With education, people will be created who are reliable and qualified to keep up with the rapid development of information technology. The government requires Indonesian citizens to study for 9 years from elementary, middle and high school levels.

Education must always be developed so that education becomes better and meets the objectives (Septian, 2018). Good education must of course be supported by ideal learning. Ideal learning activities are a hope for every school member, especially students. According to Government Regulation no. 19 of 2005 article 42 paragraphs 1 and 2 concerning educational infrastructure standards that every educational unit is required to have facilities which include furniture, educational equipment, educational media, books and other learning resources as well as other equipment needed to support an orderly and sustainable learning process .

One of the sciences that is useful for explaining natural phenomena is physics (Taqwa et al., 2019). Physics is a branch of science that explains natural phenomena and all interactions that occur in

nature (Setia et al., 2017). Physics is often considered difficult by students. Because in the learning process, physics does not only prioritize product aspects, but must also be balanced with process aspects (Zainuddin et al., 2021). Apart from being considered difficult, physics is also often considered a boring subject for students (Pasaribu, 2017). According to Jufrida et al (2020) in science learning, especially physics learning, teachers should guide students to be able to carry out investigations or observations.

The aim of observation activities is to help students gain knowledge independently (Lambantoruan et al., 2019). One of the approaches taken and related to scientific activities or observations is science process skills (Herman & Yusuf, 2017). Science process skills are the assimilation of intellectual skills applied in the learning process (Nehru & Syarkowi, 2017). Apart from that, science process skills are the most frequently used thinking skills (Chusni et al., 2018). Students who cannot apply science process skills will find it difficult in everyday life, because science process skills are not only used in the field of education, but are also used in everyday life. Sutiani et al., 2021.

According to Laugksch, (2000) science process skills have an important role in the learning development process of students in the classroom. Apart from that, according to Hrouzková & Richterek (2021) Science process skills are provisions for students to be able to implement scientific methods in developing knowledge. So science process skills need to be mastered by participants (Martawijaya et al., 2023). According to (Khurma, 2023) Science process skills are students' ability to apply scientific methods in understanding, developing science and discovering science.

One of the physics learning processes that does not train students' process skills is a learning process that is dominated by the role of the teacher or is teacher-centered, as a result, it does not involve students being active, which can have an impact on low learning outcomes. (Hafizah et al., 2020). During the physics learning process it only focuses on the teacher and lacks scientific process skills such as (a) making observations, (b)

collecting data, (c) taking measurements, and (d) organizing and classifying data, which means moving away from the nature of physics. (Subali & Mariyam, 2013) as processes and products resulting from the scientific method process.

The 2013 Minister of Education and Culture Regulation has also emphasized that in addition to the learning process, apart from being required to know and memorize theories, laws, principles and concepts of physics, students are also expected to have the ability to understand and apply concepts, have the ability to analyze, and have the ability to process science skills. (Fadhila et al., 2018). Learning by practicing science process skills has also been mandated in the Mardeka curriculum but in reality it is not implemented in schools (Lailis et al., 2021) so it does not provide learning that trains scientific reasoning.

Physics is widely used in various fields of life such as technology, education, engineering and other fields of life. However, nowadays there are still many problems that occur in the teaching and learning process. Many classroom lessons still use the lecture method (Rafiah et al., 2018). Teachers still implement learning that is centered on educators rather than students (Nurhayati et al., 2016), conveying material abstractly and theoretically and students passively just listen to lectures from the teacher (Jasri and Masunah 2019). The application of physics learning strategies still contains mathematical elements and is not contextual, making students think physics is a difficult subject (Nurhasanah et al., 2020). Students are rarely invited to learn related to the application of physics concepts learned in making a technological product (Nuraini et al., 2023). Generally, students are aware that physics is important and useful in everyday life so it needs to be studied, but in reality they do not understand the use of physics in everyday life (Usmeldi, 2016). This happens because the learning process developed by teachers is weak and students are less active in learning physics. The impact of students' weak science process skills has an impact on learning processes that do not run properly and low student learning outcomes (Martawijaya et al., 2023).

The low learning outcomes for science, especially physics, become increasingly clear when looking at the results of tests, final semester exams and even final school exam results. In almost every final school exam, the physics subject tends to have the lowest score when compared with the scores of the subjects that are also tested. Research conducted by Rohman et al. (2017) shows that the average physics score obtained by students in the final even semester exam at one of the high schools in Piyungan was 63.5. This shows that physics learning is said to be less successful because it has not reached the minimum completion criteria determined by the school, namely 65. In the research results, it is also stated that there are still many students who have not completed the score below the KKM and therefore have to take part in remediation.

Based on the explanation above, models and approaches are needed so that students' learning objectives are achieved. The student-centered learning model is project-based learning. Project-based learning involves students in learning which can increase motivation and enthusiasm for learning (Sari & Susiani, 2021). Project-based learning can hone students' abilities to analyze and critically evaluate important aspects of literacy (Sirait & Amnie, 2023), helps introduce and enhancing students' technological literacy (Simanjuntak et al., 2023), effective in mening. The aim of the research is to determine differences in understanding of science process skills in physics subjects at SMA Negeri 1 Piyungan through the application of the STEM-project model to enhancing

Materials and Methods

This research is a type of development research. The choice of development design for the module uses the ADDIE model developed by Reiser and Mollenda. Tageh (2014) stated that the ADDIE model is a systematic development design model and is based on the theoretical foundation of learning design. The implementation plan for the ADDIE model can be seen in Figure 1.



Figure 1. ADDIE Model Design

Researchers must carry out this stage systematically. This research was carried out in the odd semester of the 2023/2024 academic year at SMA Negeri 1 Piyungan. The methods used to collect data in this development research are observation, interviews, validation questionnaires, teacher response questionnaires and student response questionnaires. This research develops a product, namely a STEM project model book for science skills in physics subjects. In this research, the media will be tested by experts (media experts), language experts and physics experts. The data analysis used in this research is descriptive analysis, data was obtained from questionnaires given to media experts, material experts, teacher responses and student responses.

Results and Discussion

STEM learning has succeeded in changing from a standard teaching model to a teaching model that emphasizes innovation and problem solving. This research really supports the application of the current curriculum to solve a problem. Research on innovation in science learning concludes that the STEM project model can be used as a learning innovation to build 21st century skills and can build science skills in physics subjects.

1. Analysis Stage

Science process skills are the skills to process information obtained from the teaching and learning process which provides opportunities for students to be able to observe, classify, interpret, predict, apply, plan and evaluate the experimental results obtained. Science process skills are very important for students to master. Due to the

development of science, knowledge occurs so quickly that it is no longer possible to teach facts and concepts to students. Apart from that, science process skills can also train habits in scientific thinking to be able to solve problems in everyday life Lawson (2010). So with science process skills, students can also think critically.

At this stage the researcher conducted a field study to gain an understanding of science skills in physics learning. In this analysis stage, the researcher conducted preliminary research, namely through interviews and observations of the physics learning process at SMA Negeri I Piyungan. With the aim of obtaining student needs. At this time in the learning process students are still less active in asking questions. So it can be said that students only accept what the teacher explains, without exploring in depth the material presented by the teacher. Therefore, it can be concluded that students' science process skills are still in the low category.

Students' inactivity in asking questions and exploring the material illustrates their lack of desire to understand the concept as a whole. This can be caused by several factors, such as less interactive teaching methods, a lack of a supportive classroom atmosphere, or even students' lack of confidence in asking questions. Science process skills should include the ability to observe, investigate, and understand natural phenomena in a critical way.

The results of this researcher are supported by Nguyen et al., (2020) stated that the importance of developing science process skills lies not only in understanding certain concepts, but also in students' ability to relate and apply this knowledge in the context of everyday life. Therefore, learning approaches that encourage active student participation, such as group discussions, practical experiments, and problem solving, become very relevant in improving science process skills.

This is also supported by research results from Baran et al., (2021) explains that it takes joint efforts between teachers, schools, and parents to adopt teaching methods that motivate students to ask questions, stimulate their curiosity, and develop critical thinking skills. Meanwhile, schools can create facilities and policies that support

interactive learning activities. Parents also have an important role in encouraging their children's desire to learn, both inside and outside the school environment.

2. Design Stage (Design).

Designing a STEM project model is an important step in developing a successful STEM project. This design stage involves careful planning to ensure that the project can be executed efficiently and achieve the desired STEM education goals. Following are some steps that can be followed in the design stage of a STEM project model

Table 1.STEM Model Design Stages

No	Aspect	Description
1	Material Contents	At this stage the researcher creates the basic concept of the STEM project model starting from determining the context to introduce the topics that will be discussed in the STEM project model. Clearly define the learning objectives to be achieved through this STEM project model. Make sure the objectives are related to the Physics concepts that will be taught. Explain the concepts briefly, explaining the steps or processes that will be followed in the STEM project. Make sure the experiment is in accordance with the Physics concepts being taught. Provide instructions on how to use the device. The initial design for this research began with a model design process that was adapted to the characteristics of high school students so that it was easy to understand, which was checked by material experts.

No	Aspect	Description	No	Aspect	Description
2	Create illustrations or model concepts	<p>Creating an illustration or concept model for a STEM project is an important step in designing a STEM project. This illustration or concept will help students visualize the project before implementation. The following are the steps in creating an illustration or concept model for a STEM project:</p> <ol style="list-style-type: none"> The layouts of children's model books that are created certainly have very varied characteristics or styles, compositions and designs. Some common points that can be found in STEM project model books include: boxed, vignette, full bleed, and spot. The size of the illustration uses an illustrative style from small pictures then gradually to a full page until the end of the story, it can also be the opposite. The function of small images is to show image illustrations in more detail or clearly. The rhythm and pattern of children's STEM project model books generally have a model pattern or flow as well as dynamic STEM project model steps. These patterns and rhythms can be seen from strong story depictions or text support contained in a 			<p>STEM project model book</p> <ol style="list-style-type: none"> Typography in a STEM project model book must pay attention to elements of convenience and clarity with the aim of making it easier for students to use the model. Apart from the points mentioned above, Trapani (2013) stated that most books have an average size of 20.32x25.4 cm.
			3	Product specifications	<p>At the product specification stage, a model design is designed to create:</p> <ol style="list-style-type: none"> The resulting product is a STEM project model book STEM project model book consisting of cover, model contents The STEM project model book is based on PBL and STEM theory (STEM-Project)

The results of research on designing STEM project models show that a systematic and planned approach is crucial to achieving the success and effectiveness of STEM education projects. In the design stage, strategic steps have been identified and implemented to ensure the project can run efficiently and achieve the desired STEM education goals.

Based on the careful and comprehensive design of the STEM project model, it is hoped that the project can make a significant contribution to the development of students' STEM skills, motivate their interest in the fields of science and technology, and prepare them to face the demands

of an increasingly complex and changing world of work. Thus, designing a STEM project model is not just about designing an educational activity, but also about shaping students' futures in the ever-developing STEM era.

3. Development Stages (Development)

The STEM model development stage is the step where you start designing and creating the entire STEM project or program that you will implement. This stage involves preparing materials, developing tools, and all the elements needed to carry out a STEM project. The following are the stages of developing a STEM model: 1) in terms of the concept of correctness, 2) accuracy (does not result in conceptual errors), 3) durability, 4) resilience, 5) security, 6) suitability for size, 7) flexibility. Products that have been printed in physical form and also in digital form will then be validated by experts, namely material experts and media experts so that researchers can determine the suitability of the media products being developed where the results obtained are as follows:

Table 2. Results of Media and Material Expert Assessment Analysis

Assessment Aspects	Score					Σ_s	V
	S1	S2	S3	S4	S5		
Material	23	29	27	27	28	137	0.91
Language	11	12	11	11	11	56	0.93
Average Validity							0.94%

The results of the validation test carried out by the material expert obtained a result of 94%, where the results showed that in the validator test carried out by the material expert in the STEM-project model book, it was suitable for testing on physics students. This was said to be feasible because it met 2 aspects, including language. which includes (simplicity of language, appropriate terms, using PUEBI, writing layout) and content aspects which include (easy to understand, story title, appropriate to children's daily life, appropriate number of pages).

The application of the STEM-project model is needed to hone science process skills in physics subjects. Even the application of the STEM-project model can encourage students to think creatively and as many as 80.54% gave a positive response to the application of the STEM-project model. Winnie, (2023) stated that there are several benefits of the

STEM-project model, namely that it makes students able to solve problems better, be innovative, independent, think logically, and be technologically literate. Thus, the application of learning using the STEM-project model has been proven to be able to enhancing student learning outcomes, especially in physics subjects.

4. Implementation Stages (Implementation)

The implementation stage of the STEM-project model is the time where you carry out the STEM project that you have developed. Implementation is a key stage in running a STEM model successfully. The following are the stages of implementing the STEM-project model: 1) cover design, 2) content suitability.

The implementation of the STEM-project model was carried out well overall, researchers carried out a series of activities as follows:

- a. Researchers introduced model products to students through product presentations in front of the class using an LCD projector that displayed STEM-project models
- b. Researchers distributed student response questionnaires after the introduction of the STEM-project model was completed.
- c. Researchers introduce STEM-project model products to physics teachers
- d. The teacher response questionnaire assessment is carried out after the teacher checks the media created.

In the implementation phase, it was carried out in two stages, namely pretest and post-test, which were carried out on students at SMA Negeri 1 Piyungan. Implementing the STEM project model for science skills in physics subjects required patience and support to provide an in-depth and student-centered learning experience. Involving students in the scientific process will help them understand Physics concepts better while developing crucial science skills.

5. Evaluation Stage (Evaluation)

At this stage the researcher evaluates the results of the questionnaire filled out by teachers and students. If the response to the learning media is not optimal, then revisions are carried out to produce the final product. The effectiveness of

learning media in the form of a STEM-project model can be seen from surveys of children and teachers.

a. Assessment Results Raise teacher responses

Table 3. Teacher Response Assessment Results

No	Rated aspect	Total score
1	Conformity Aspect	3
2	Language Aspects	3
3	Study Aspects	3
4	Aspects of effectiveness for children	3
5	Feasibility aspect	2
Score		15
Maximum Score		15
Percentage		93%
Criteria		Very good

Based on table 3, the results of the teacher response questionnaire can be seen to have a percentage of 93% in the "very good" category. From these results it can be concluded that digital-based storybook learning media can enhancing the moral intelligence of young children and can be used.

b. Assessment of Learning Outcomes in Science Skills

Table 4. Student Response Assessment Results

No	Value Predicate	Student Freq	Average Value	Criteria
1	Very Good (89-100)	2	90%	Very good
2	Good (77-88)	16	70%	Good
3	Enough (77-88)	6	79%	Good
4	Failed (<65)	0	-	-
Average			80%	Very good

Based on the research results, it can be seen that students' science skills, especially in physics subjects, generally reach a satisfactory level. Table 4 shows that the average ability of students' science skills in the process aspect reached 80%, which is in the good category. This indicates that students are able to carry out scientific processes well in the context of physics learning.

It is important to understand that the process aspect of science skills includes various stages, such as observation, measurement, data analysis, and the ability to organize and present information. With an average of 80%, it can be interpreted that the majority of students succeeded in demonstrating their skills in carrying out these stages adequately. This success can be caused by various factors, including the teaching methods used, the availability of resources, and the level of student participation in learning activities. Thus, these results provide a positive picture regarding efforts to enhancing students' science skills in physics subjects.

c. Pretest and Post-test Results for Science Skills in Physics Subjects

Table 5. Pretest and Post-test Results for Science Skills in Physics Subjects

No	Indicator	Pre-test	Category	Post-test	Category
1	Observe	73.21	Good	73.44	Good
2	Grouping	51.79	Not enough	76.56	Good
3	Applying Concepts	58.93	Enough	78.13	Good
4	Predict	55.36	Enough	71.88	Good
5	Interpret	50.00	Not enough	65.63	Enough
6	Designing Experiments	51.79	Not enough	68.75	Enough
7	Using Tools and Materials	55.36	Enough	65.63	Enough
8	Submit Question	55.36	Enough	67.19	Enough
9	Communication	48.21	Not enough	70.31	Good
10	Hypothesis	44.64	Not enough	67.19	Enough
Average Percentage		54.46	Not enough	70.47	Good

Based on Table 5 above, it shows that there is quite a significant difference in the results of the pre-test and post-test in science process skills, with the average percentage of all aspects of science process skills in the pre-test being 54.46% in the poor category while in the post -test average percentage of students' overall science process skills was 70.47% with a good category. The highest aspect in the pre-test was observing with an average percentage of 73.21%, in the good category and for the post-test the highest was in the aspect of applying concepts with a percentage of 78.13% in the good category. Meanwhile, the lowest average percentage value of the pre-test was in the hypothesis aspect with an average percentage value of 44.64% for the poor category.

The application of the STEM-project model makes students active, creative and able to work together in groups, as well as building their knowledge individually and developing science process skills in physics subjects. (Martawijaya et al., 2023). Thus, it can be concluded that there is an influence on science process skills using the STEM-project model.

The development of a STEM-project model in improving science process skills in high school physics subjects has a significant impact on learning approaches and student achievement. This finding is supported by research results Maulana et al., (2023) revealed that engaging students in STEM-projects encourages the application of scientific skills, critical reasoning, and problem solving in a physics context. In the aspect of science process skills, STEM-projects help students develop observation, measurement and experimentation skills. These processes allow students to understand physics concepts in depth through direct experience, thereby increasing understanding of the concepts and relating them to the real world.

Additionally, STEM-projects also facilitate the development of collaborative and communication skills. Students learn to work together in teams, share ideas, and communicate their findings, creating a learning environment that promotes cooperation and creativity. This creates opportunities for students to develop interpersonal skills that are so necessary in the real world. The implications of these findings are very relevant in the context of the high school physics curriculum which places greater emphasis on the application of concepts and skills, rather than simply receiving information. By involving students in STEM projects, teachers can design learning that is more contextual and relevant, motivating students to learn actively and deeply.

Conclusions

Based on the research results above, it can be concluded that the research results are 1) The average result of the feasibility test assessment of material aspects is 91% validity with a very valid

category with very good category and the media aspect is 93% very valid validity (2) The average results The module readability assessment was 80.67% in the very good readable category. (3) The average result of student response assessment to the module is 80% in the very good category. (4). The average result of the teacher response assessment to the module was 93% in the very good category. . This means that the STEM project model can have a significant and effective influence on improving understanding of science process skills in physics subjects at SMA Negeri 1 Piyungan. Apart from that, both men and women showed a positive and happy response to the application of the STEM project model for science process skills in physics subjects. According to students, learning is interesting and motivating; can help understand teaching material, form creative attitudes, and students become increasingly aware of the importance of protecting the environment.

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