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Development of STEM-Based Instructional Tools to Enhance Students' Creative Thinking Skills

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Abstract

This study aims to develop STEM-based instructional tools to enhance students' creative thinking skills. The research method used is the ADDIE development model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The subjects in this study were two science teachers and 30 seventh-grade students of MTs NU Nurussalam. At the analysis stage, teachers need STEM-based learning tools for active learning. The design stage includes teaching modules, student worksheets (LKPD), evaluation tools, and a science kit (KIT). The implementation is carried out through socialization and the learning process. The evaluation was conducted using questionnaires administered to both teachers and students. The results showed that the STEM-based learning tools were well received, with 93% of teachers stating that the tools were easy to implement and 87% of students stating that the learning was enjoyable and motivated them to think creatively. In addition, students' creative thinking skills increased after the learning process, as indicated by an N-Gain score of 0.7, categorized as high. This study concludes that the developed STEM-based learning tools are effective in increasing student engagement and creative thinking skills, and are suitable for use in science learning at the madrasah level.

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INTRODUCTION

Natural science learning involves an integrated understanding of concepts and practical activities to equip students with the knowledge and skills necessary to explore natural phenomena scientifically (Syamsudin et al., 2017). Students are encouraged to engage in independent inquiry, with teachers providing guidance in solving problems. Teachers can design instructional tools that accommodate students' needs and develop them innovatively, focusing on enhancing students' competencies (Cahyono et al., 2023).

Science learning tools consist of five main components, namely teaching modules (RPP), learning media, student worksheets (LKPD), teaching materials, and creative thinking skills assessments (Oktapiani & Hamdu, 2020). The development of these learning devices must refer to scientific principles and approaches, as well as the STEM approach, which emphasizes the integration of science, technology, engineering, and mathematics in real life. The STEM approach encourages students to apply cross-disciplinary knowledge to solve contextual problems through creative design and exploration processes (Lawe & Meo, 2018). However, observations show that learning devices in the field still predominantly use lecture and question-and-answer methods, without variations in learning models that hone students' critical and creative thinking skills (Cahyono et al., 2023).

Teachers play an important role as motivators, moderators, and facilitators who deliver material through learning tools, so teachers' insight into these tools greatly determines the success of learning (Herawati, 2022; Pangestu & Susanti, 2022). An effective learning process should be student-centered and actively involve students in data collection, problem formulation, hypothesis development, and experimental design (Lawe & Meo, 2018).

n line with the demands of 21st-century education, creative thinking skills are one of the important competencies that must be developed in students. Creative thinking is the ability to produce unique ideas and new solutions that are relevant to solving problems (Putri & Alberida, 2022). Indicators of creative thinking include fluency, flexibility, originality, and the ability to develop detailed ideas (elaboration).

Factors that support creativity include the ability to view problems from various perspectives, in-depth knowledge, diverse thought patterns, high motivation, a supportive environment, and a personality that is willing to take risks and persistent (Putri & Alberida, 2022). All of these factors can be facilitated through a learning approach that integrates STEM principles.

One of the most relevant models for developing these skills is STEM-based Project-Based Learning (PjBL). This model allows students to be directly involved in inquiry, exploration, and solution-making processes for real-world problems, making it highly effective in fostering scientific creativity and higher-order thinking (Fahmi & Wuryandini, 2020). STEM education enables teachers to teach students concepts, principles, and techniques of science, technology, engineering, and mathematics in an integrated manner, both in the classroom and in everyday life (Ifah et al., 2025). Through project-based learning, students are trained to identify problems, design solutions, use technology, and evaluate their project results reflectively, all of which are core practices in STEM learning (Prasetyo et al., 2025).

Unfortunately, the implementation of STEM in schools still faces various obstacles, primarily due to teachers' difficulties in developing learning instructions that are appropriate to student characteristics, the applicable curriculum, and local school conditions. These challenges arise from a limited understanding of comprehensive STEM implementation, a lack of relevant and contextual teaching tools, and a heavy administrative burden that reduces teachers' opportunities for innovation in lesson planning. In addition, teachers often experience weaknesses in technology literacy (Abdulazeez et al., 2024). As a result, the potential of the STEM approach to improve students' creative thinking skills has not been fully utilized (Syamsudin et al., 2017).

Good science learning is not limited to transferring concepts from teacher to student but must also provide meaningful hands-on experiences through experiments, observations, collaborative discussions, and technology exploration. The use of the STEM approach in learning tools encourages students to view science as an integral part of real life and fosters a spirit of innovation (Lawe & Meo, 2018).

Therefore, teachers as facilitators and learning designers must possess knowledge and skills in developing STEM-based science learning tools that foster creative thinking skills. Learning devices designed by combining scientific approaches, STEM principles, and the PjBL model will be highly effective in shaping students to become creative, innovative, and adaptive to the challenges of the 21st century (Anggela et al., 2022).

METHOD

This study is a type of Research and Development (R&D) that aims to produce STEM-based science learning tools oriented toward students' creative thinking skills. The development model used in this study refers to the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), as shown in Figure 1 (Cahyadi, 2019).

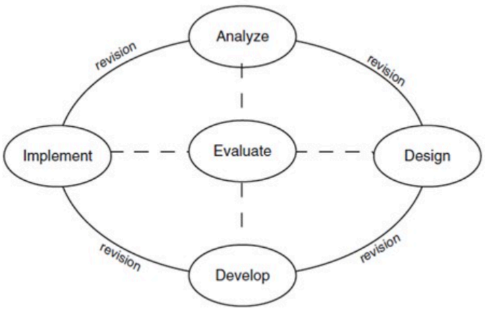

Figure 1. ADDIE model development design

Through the ADDIE model, the learning development process becomes more focused, relevant, and impactful (Ranuharja et al., 2021). The first stage is Analysis, in which learning needs, student characteristics, as well as constraints and potentials of the learning environment are identified. The results of this analysis become the basis for the next stage. Furthermore, at the Design stage, a learning strategy is formulated, including objectives, materials, methods, media, and evaluation instruments to be used. This design serves as a reference in the process of developing learning products. At the Development stage, all plans that have been prepared are realized into actual products, namely teaching modules, learning kits, student worksheets (LKPD), and multiple-choice test questions oriented toward creative thinking skills. The completed products are then validated by three experts and revised according to the feedback received. The experts provide assessments using a Likert scale ranging from 1 to 4. At the Implementation stage, the developed learning tools are tested or applied directly in the classroom. Teachers conduct lessons in accordance with the provided tools. Finally, the Evaluation stage is carried out to assess the quality and effectiveness of the learning process. This evaluation is based on the results of questionnaires completed by teachers and students, who provide assessments using a Likert scale of 1–4 related to the implementation of the learning. In addition, pretests and posttests are administered to measure students' creative thinking skills. To determine the improvement in these skills, the N-gain formula was used and categorized accordingly. The sample in this study consisted of two science teachers and 30 students of class VIIA at MTs NU Nurussalam, taken from a total population of five class VII groups.

$$\text{N-Gain} = \frac{\text{Posttest} - \text{Pretest}}{100 - \text{Pretest}}$$

Table 1. N-gain score categories

N-Gain Range	Category
≥ 0,7	High
0,3 – 0,69	Medium
< 0,3	Low

RESULT AND DISCUSSION

This study develops STEM-based science learning tools oriented toward improving students' creative thinking skills by employing the ADDIE development model (Analyze, Design, Develop, Implement, Evaluate). The following section presents the results and discussion of each stage.

1. Analyze

The results of the initial analysis show that the science learning tools used by teachers are still oriented toward conventional methods such as lectures and question–answer sessions, with the use of student worksheets (LKPD) limited to textbook-based questions (Cahyono et al., 2023). Such practices do not support the development of students' creative thinking skills, including fluency, flexibility, originality, and elaboration (Putri & Alberida, 2022). In addition, the integration of STEM concepts in existing learning devices is still minimal, making them less effective in increasing students' interest and motivation to understand science materials in an applicable and contextual manner. Based on the needs analysis, the development of STEM-based science learning devices equipped with a STEM KIT is considered a strategic solution to improve the quality of learning. A STEM KIT provides practical materials and tools that enable students to actively conduct experiments and hands-on activities. Through direct involvement in assembling models, testing hypotheses, and modifying results, students engage in a more interactive and meaningful learning process. This approach also bridges theory with real-world applications, allowing students to gain a deeper and more relevant understanding of STEM concepts.

The use of a STEM KIT also encourages students to think creatively and solve problems through hands-on experiences. Projects designed with the KIT provide challenges that stimulate students' curiosity and creativity in generating solutions (Anggela et al., 2022). In addition, students' self-confidence can be enhanced as they are able to complete practical assignments independently or collaboratively, making the learning process more engaging and effective.

However, several important inputs must be considered in developing the device, including: (1) incorporating the concept of STEM–SDGs (Sustainable Development Goals) so that the learning device integrates global sustainability issues, making learning more contextual and meaningful; (2) providing an explicit explanation of which SDGs are associated with each learning module to ensure that students understand the contribution of learning to sustainable development; and (3) improving the evaluation sheet by adding scoring rubrics to provide clearer and more measurable feedback for both teachers and students. These inputs serve as an essential foundation for designing a comprehensive STEM-based science learning device oriented toward the development of students' creative thinking skills.

2. Design

Based on the results of the needs analysis, researchers developed STEM-based science learning devices focusing on the topics *Characteristics of Living Things* and *Measurement*. The developed learning devices consist of several main components, namely teaching modules, a KIT, student worksheets (LKPD), and evaluation sheets. As a practical learning medium, the research team designed the Gecoseed KIT (Gardening with Ecoseedling), an environmentally friendly planting media KIT that utilizes used plastic bottles as planting containers. The planting medium in this KIT combines soil, fertilizer, and paper pulp as organic materials, while mustard seeds were chosen as the planted commodity. Thus, this KIT not only facilitates direct experimental activities but also teaches principles of sustainability and environmentally friendly resource management.

The learning device is designed with a STEM-based approach, emphasizing the integration of Science (understanding scientific concepts), Technology (the use of

KIT media), Engineering (the design and utilization of the Gecoseed KIT), and Mathematics (measurement and analysis of experimental results). Furthermore, learning activities are linked to global issues through their association with the Sustainable Development Goals (SDGs), particularly Goal 15, *Life on Land* ("Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss"). Governments and all elements of society, including students, are obliged to protect and manage the environment in order to achieve sustainable development (Sahrir et al., 2024). This integration is intended to help students recognize the relationship between science learning and environmental conservation efforts, while simultaneously fostering strong ecological awareness.

The evaluation component of the learning device includes a set of test questions designed to provide a quantitative assessment of students' creative thinking skills during the learning process. With this design, the learning device not only offers engaging content and media but also supports the integrated development of students' creative thinking skills and environmental awareness. The learning steps are as follows:

A. Preliminary Activities (10 Minutes)

1. The teacher opens the lesson with greetings and prayers, pays attention to student readiness, neatness of clothing, neatness of position, neatness of seating, and checks student attendance.
2. The teacher conveys the objectives to be achieved in learning
3. The teacher and students prepare the equipment that will be used during learning.
4. The teacher conducts apperception by asking about previous material and linking the material to be learned

B. Core Activities (60 Minutes)

Step 1: Orienting students to the problem

a. The teacher gives students a trigger question

   The trigger question:

   1. Children, have you ever observed plant growth?
   2. To record growth results, what units of measurement are usually used? Centimeters or meters?

Step 2: Organizing students to learn

a. The teacher explains the material on physical quantities and measurements briefly and clearly, using a scheme.
b. The teacher provides information on various quantities and measurements.

Step 3: Guiding individual investigations

a. The teacher links the measurement material with the activity of observing plant growth.
b. The teacher invites students to discuss problems in plant growth related to environmental problems by conveying several statements (regarding SDGs or sustainable development goals, the topic of maintaining terrestrial ecosystems)
c. The teacher provides a trigger statement about existing problems related to SDGs (the topic of maintaining terrestrial ecosystems), related to plant growth activities by utilizing narrow and limited environments.

   Trigger questions:

   1. Have you ever imagined whether the land around us is decreasing?
   2. What would you do if you wanted to be able to plant in narrow and limited land?

Step 4: Developing and presenting the results of the work

a. The teacher asks several students to put forward their ideas.
b. Students convey their ideas as creatively as they can.

Step 5: Analyzing and evaluating the problem-solving process

a. The teacher and students analyze and provide responses and input from the delivery of the results of other groups.
b. The teacher evaluates the results of the problem analysis that have been discussed together.
c. The results were decided in the form of making a vertical plant growth project or hanging garden using pots and a mixture of planting media from used goods (pots from packaging bottles, and planting media from

paper pulp), aimed at planting activities in limited environments.

d. The teacher divides students into several groups, then provides instructions and a brief explanation of the project activities that will be carried out in the next meeting.

C. Closing (10 Minutes)

1. The teacher and students conclude and reflect on the learning outcomes of this meeting.
2. Reflection of student achievement or formative assessment to determine student achievement in learning.
3. The teacher informs the students about the learning activities that will be carried out in the next meeting
4. The teacher ends the learning by giving messages and motivation to students, then continues with prayer and greetings.

The developed LKPD design

a. Objectives

1. Able to identify the characteristics of living things.
2. Able to classify living things based on their characteristics.
3. Able to apply the principles of measuring physical quantities, significant figures, and scientific notation.
4. Able to present the results of measuring physical quantities following the rules of significant figures.

b. Tools and Materials

1. 2 pieces of used bottles as pots
2. Planting media (soil, compost, paper pulp)
3. Hemp rope
4. Plant seeds
5. Ruler

c. Work Steps

1. Prepare the materials to be used
2. Make a planting medium from the materials provided using a ratio of 2 (soil): 1 (compost) and mix the pieces of paper with water to form paper pulp.
3. Make a hanging pot with a bottle pot using a rope to hang the pot vertically
4. Put the planting medium into the bottle pot
5. Put the plant seeds into the pot
6. Cover the plant seeds again with soil
7. Water with enough water
8. Hang the pot in a place exposed to sunlight
9. Observe the growth process of the plant

d. Observation Results Table

Table 2. Observation results

Day to-	Treatment (Watering)		Plant Growth (cm)	
	Yes	No	Soil media	Paper pulp media
1				
4				
7				
10				

Description: Check the Yes/No column.

e. Questions

1. What factors affect the growth of the plant seeds?
2. Were there any plant seeds that failed to grow? Why was that?

What difficulties were experienced while planting the plant seeds?

Figure 2. KIT Gecoseed Media

3. Develop

Validation of the science learning device was carried out by 3 experts (V1, V2, and V3) who assessed the shortcomings and advantages of the STEM-based science learning device. The validation results are shown in Table 4.

Table 4. Media expert validation

Indicator	Assessment Aspects	V 1	V 2	V 3
Eligibility of Content and Components	The materials used in the Learning Devices are in accordance with the learning outcomes	4	4	4
	The materials used in the Learning Devices are in accordance with the learning objectives	4	4	4
	The materials presented in the Learning Devices are complete	4	4	4
	The materials described in the Learning Devices are clear	3	4	4
	The materials are presented sequentially	4	4	4
	Examples of problems in the Learning Devices are presented clearly	4	4	4
	Practice questions and simple experimental procedures in the Learning Devices are presented clearly	3	3	3
	The Learning Devices can be used independently	4	4	4
Linguistics	Writing Learning Devices in accordance with the general guidelines for correct Indonesian spelling (PUEBI)	3	3	3
	The language used is easy to understand	4	4	4
	The language used in Learning Devices is simple and communicative	4	4	4
	Use of appropriate Latin names and chemical symbols	3	3	3
Total		44	45	45
Percentage (%)		92	94	94

The validation results of V1, V2, and V3 were respectively: 92%, 94%, and 94%. This indicates that the learning device is suitable for use. Some input from the validator are: 1) Add the number of pots from plastic bottles to facilitate student creativity in making planting media, 2) Storage containers need to be replaced in the form of plastic boxes so that the kit is safer and not easily damaged, and 3) Every meeting in the teaching module should always be related to the use of KIT.

4. Implement

The implementation phase was carried out at MTs NU Nurussalam as a trial location for the implementation of STEM-based science learning devices. The devices implemented included teaching modules, LKPD, evaluation questions, and KIT Gecoseed (Gardening with Ecoseedling). This KIT was designed from simple materials such as used plastic bottles, rope, planting media (soil, fertilizer, paper pulp), and mustard seeds, and functions as a medium for student practice in STEM-based learning. The learning material raised was "Characteristics of Living Things and Measurement", with a project-based learning approach that integrates elements of science, technology, engineering, and mathematics (STEM). This learning is also oriented towards Sustainable Development Goals (SDGs) number 15, namely "Maintaining Terrestrial Ecosystems". During the implementation, researchers conducted classroom observations, documentation, and interviews to record the implementation process, teacher and student responses, and obstacles that arose. The results of the observations showed that learning went smoothly and received positive responses from both teachers and students. Science learning is shown in Figure 3.

Figure 3. Science learning

Some of the obstacles identified during the implementation of STEM learning include: 1) Lack of teacher training in designing and implementing STEM learning. This can be seen from teachers who still rely on lecture methods and are less able to integrate project-based or experimental approaches in STEM learning. 2) Limited implementation time because the STEM approach requires longer exploration and discussion. Exploration and discussion activities are often hampered by the limited lesson time of only 3 hours per week. and 3) Lack of technology support and skills in its use by teachers and students. This is because schools do not yet have stable internet access, and the available technological devices are limited.

5. Evaluation

The evaluation was conducted to determine the effectiveness of the STEM-based science learning devices that had been developed and implemented. This evaluation was conducted through teacher and student response questionnaires, as well as reflections from researchers based on observations, documentation, and interviews during the learning process. The results of the questionnaire filled out by 2 science teachers and students of MTs NU Nurussalam are shown in Table 5 and Graphic 1. The results of the pretest and posttest are shown in Figure 5.

Table 5. Assessment results by two science teachers

Statements	ST 1	ST 2
The use of STEM-based learning devices with KIT gecoseed in learning is something new and interesting for me	3	4
This learning device helps students to think creatively in learning the characteristics of living things and measurements	3	4
The presentation of material in LKPD and KIT is interesting and easy to understand	3	4
The delivery of material in this learning device is related to everyday life	4	4
The presentation of material in the learning device is in accordance with learning achievements	4	4
The material presented is in accordance with the order of presentation of the concept	4	4
The steps of the activities contained in the LKPD are easy for teachers and students to understand	4	4
The teaching modules that are compiled can be understood and implemented in class	4	4
The size and type of font used in the learning device are easy to read	4	4
The language used is easy to understand	4	4
Total	37	40
Percentage (%)	93	100

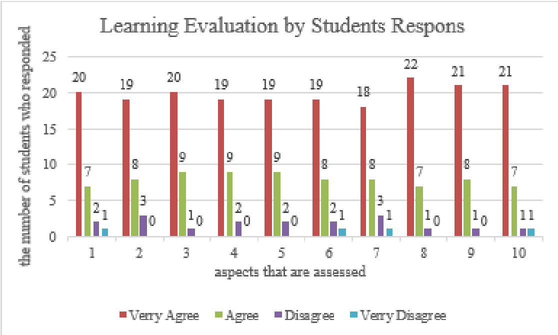

Figure 4. Learning evaluation by students' responses

The results showed a very positive response. These results indicate that the developed learning tools can enhance students' creative thinking skills. This finding is in line with the study by Sari et al. (2022), which stated that learning tools can improve creative thinking skills, with an average N-gain score of 0.63. Teachers considered that the use of the Gecoseed KIT was an interesting and appropriate innovation to develop students' creativity in understanding the material "Characteristics of Living Things and Measurement". Teachers also considered that the developed device was easy to use, had a clear flow of activities, and was in accordance with learning outcomes.

Questionnaires were also distributed to students after the learning process took place. As many as 87% of students gave positive responses. After learning, most students were more interested in science materials, motivated to learn because activities involved direct practice, and were able to think more creatively and solve challenges collaboratively. Students also showed high enthusiasm in designing and assembling KITs from used materials, and felt happy because learning felt fun, different from ordinary learning, which was theoretical. The final results of the creative thinking skills score are shown in Table 6, and the increase in each indicator is shown in Figure 2.

Tabel 6. Final score of students creative thinking skills

Creative Thinking Skills Aspects	Average Score		N-gain	Cate-gory
	Pre test	Post test		
Fluency	51	88	0,8	High
Flexibility	44	87	0,8	High
Originality	40	70	0,5	Medium
Elaboration	45	78	0,6	Medium
Average	45	80,75	0,7	High

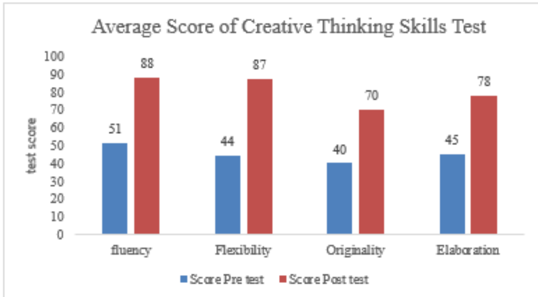

Figure 5. Results of pre-test and post-test of creative thinking skills

Table 6 shows that students' creative thinking skills have increased after the implementation of the STEM-based learning model, with an N-gain value of 0.7 in the "high" category. The "high" category is seen in two main indicators, namely fluency and Flexibility, which are 0.8 and 0.8, respectively. This is indicated by students' ability to choose answers that represent various possible solutions to the problems given. Through multiple-choice questions designed to test understanding of variations in ideas, students show an increase in their ability to identify alternative solutions quickly and accurately. The flexibility indicator also shows a high increase. Students are able to choose answers that reflect different approaches to solving a problem. This shows that students are starting to get used to thinking from various perspectives and considering non-single solution strategies. Contextual multiple-choice questions provide opportunities for students to practice flexible thinking skills in a limited space. In contrast, the originality and elaboration indicators show an increase in the "medium" category of

0.5 and 0.6. This is understandable considering that the multiple-choice question format tends to limit the space for. Overall, these findings indicate that although multiple-choice tests have limitations in measuring creative thinking skills as a whole, this question format is still quite effective in measuring fluency and flexibility of thinking as part of creative thinking skills.

Some important points of the evaluation results include: 1) The effectiveness of the learning devices developed is considered effective in developing students' creative thinking skills, as shown by students' active responses in compiling KITs, discussing, and solving the problems given. 2) Learning devices can be implemented and are in accordance with school conditions and resources. Gecoseed KITs based on used goods strongly support sustainability and can be implemented without the need for expensive laboratory facilities. 3) Teacher involvement shows openness and enthusiasm in implementing the devices. 4) Learning has succeeded in integrating the concepts of STEM and SDGs 15 by emphasizing the importance of maintaining terrestrial ecosystems through direct practice in planting and caring for plants. This makes learning more contextual and meaningful for students.

CONCLUSION

The results of the study indicate that the STEM-based science learning devices developed have met the feasibility aspects in terms of content, STEM integration, and usefulness in learning. The learning devices in the form of teaching modules, LKPD, KIT Gecoseed, and evaluation sheets have successfully integrated the STEM approach with the context of the 15th global issue of SDGs concerning the preservation of terrestrial ecosystems. Teachers gave a positive response to the device, with an acceptance rate of up to 93%, indicating that the device is easy to understand, interesting, and relevant to science learning. Students also gave a very good response, namely 87%, to the implementation of the learning device. In addition, students' creative thinking skills increased after learning in all indicators. In the aspects of fluency and flexibility, each is 0.8 with a high category; in the aspect of originality, it has a value of 0.5 with a medium category; and in the aspect of elaboration, it has a value of 0.6 with a medium category. KIT Gecoseed-based learning provides a fun and meaningful learning experience because it combines direct practice with real problem-solving. These results show that the developed learning tools are not only feasible, but also effective in supporting science learning that is oriented towards 21st-century skills, especially creative thinking.

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