



Improving the Attitudes and Creative Thinking Skills of Senior High School Students Using an ESD-Enhanced STEM Approach

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Abstract

The STEM approach is a learning strategy to train students' creative thinking skills. This approach encourages students to conduct the engineering process by making prototypes or products to solve problems. Education for Sustainable Development (ESD) needs to be integrated into STEM learning to train students' thinking and questioning skills. This study aims to determine the improvement of ESD attitudes and creative thinking skills by using the ESD-integrated STEM approach. This study used a one-group pretest-posttest design. The research instruments used were a creative thinking skills test with creative thinking indicators and an ESD attitude questionnaire. The N-Gain test analysis obtained a result of 0.81 with a high category. The results showed that students' creative thinking skills improved significantly, and students' ESD attitudes improved very well through the STEM approach with ESD content in high school students. This research shows that the STEM approach with ESD content can be used as an alternative learning method to improve students' creative thinking skills and can contribute to the development of science by enriching the understanding of the STEM approach with ESD content, presenting a new perspective in education that focuses on sustainability and creativity.

Keywords: Creative thinking skills; ESD; STEM approach

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INTRODUCTION

Science and technology are developing quickly, impacting many facets of human life, including education. The primary potential of high-quality human resources can be developed through education (Mawarni & Abdullah Sani, 2020). The accomplishment of present educational objectives is crucial, particularly the social component, from the standpoint of national growth. The

concept of Education for Sustainable Development (ESD) emerged from our day's environmental and humanitarian issues and the difficulties of the future. In order to improve people's quality of life, ESD is founded on the principles of sustainable development as an autonomous and interconnected dimension between socio-cultural, environmental, and economic factors (Ali et al., 2020). Science, social skills,



creativity, problem-solving abilities, and individual and collective responsibility are all fostered by ESD (Suharyani & Siswanto, 2022). ESD aims to foster beliefs and abilities that will enable individuals to conserve the environment and advance society. People must realize that their behaviour patterns impact the environment.

Accordingly, environmental, social, and cultural values ought to inform behavior patterns (Suharyani & Siswanto, 2022).

ESD can be incorporated into the curriculum at all levels when learning is implemented. All stages of education, from elementary to secondary, can support the educational process that prepares children to be responsible adults and to advance sustainable development in local and global contexts (Eilks, 2015; Imara & Altinay, 2021). According to Dannenberg & Grapentin (2016), this approach can present a new culture and direction in the world of education, both in terms of content and learning methods. As a physics teacher is required to be able to keep pace with the rapidly growing development of science and technology, including ESD, teachers must be able to develop and implement approaches, methods and strategies in learning that integrate with ESD competencies in the learning process during teaching and learning activities. In schools, it is very important to implement sustainable education to change attitudes towards using future energy sources.

Creative thinking skills are not only owned by a handful of individuals but in theory, creative thinking skills can be obtained by all students (Akyıldız & Çelik, 2020; Davis, 2018). Students' creative thinking ability is one of the abilities that can encourage students to improve their creativity and effectiveness in their problem-solving abilities. Mulyasa (2020) asserted that students who struggle with creative thinking find solving challenges during the learning process challenging. Learning fosters the

development of creative thinking abilities, which include originality, fluency, flexibility, and elaboration. The ability of students to think creatively in physics is, in fact, not in accordance with the facts in the field. Based on observations at SMA N 3 Pemalang, physics learning is still teacher-centred; the teacher still explains the material using power points, and the method used is also conventional, namely the lecture method. This causes students to have difficulty solving physics problems, thus reducing students' creative thinking skills. Creative thinking is based on the use of intuitive and rational thinking, with a focus on using information to explain original things, create new ideas, and find constructive perspectives (Baer, 2014; Klentien & Wannasawade, 2016; Syahrir, 2019; Yildiz & Yildiz, 2021). By encouraging students to think creatively and differently during learning sessions, this educational learning tool is very effective in this process, leading to the improvement of students' creative thinking skills, especially in physics learning. It has been clearly explained that creative thinking is a combination of logical thinking and divergent thinking that is based on conscious intuition (Béres & Fook, 2019; Pehkonen, 1997). Learning models and the STEM method can help students build their creative thinking skills to train their creativity and understand the physics material presented by the teacher.

Using STEM as a teaching strategy offers a way out of difficulties when implementing an autonomous curriculum. STEM education teaches students how to create goods, procedures and systems that improve human life by integrating ideas and concepts from science, technology, engineering and math (Ardiyanti et al., 2022). The STEM approach can potentially optimize cross-curricular projects using high individual student skills so that teachers and students can manage time and available

learning. It can cover a variety of disciplines and has the potential to help students and teachers develop problem-solving skills, sophisticated thinking, environmental awareness, independence, and responsibility (Fakhrudin et al., 2021; Saat et al., 2021). The STEM approach focuses on driving innovation and supports students in developing advanced thinking and creative skills (Abdurrahman, 2019; Stehle & Peters-Burton, 2019; Wahono et al., 2020). Implementing STEM in learning is practical (Sulaeman et al., 2020). STEM education in learning can eliminate traditional learning that separates the four disciplines, and STEM integrates the four disciplines and applies them to the real world to make learning relevant to students (Mu'minah & Aripin, 2019).

The results of research conducted by Putra (2023) show that STEM has a high influence on students' concept understanding and creative thinking skills in physics learning, so students' creative thinking skills which initially had not increased have increased. This happens because physics learning uses Ethno-STEM teaching materials with Newton's Law material, which increases students' creative thinking skills. Based on this research, the researchers examined the STEM approach with ESD content to improve students' ESD attitudes and creative thinking skills. The difference in this study is that it uses ESD, and the material used is static fluid. ESD is expected to encourage students to be more responsible for sustainable issues.

Based on the description above, the use of the ESD-loaded STEM approach for high school students is still limited, so this study aims to determine the improvement of attitudes, especially ESD attitudes and creative thinking skills using the ESD-loaded STEM approach.

METHOD

Pre-experimental research falls into this category. Only a small percentage of subjects were included in the pre-experimental design, which allowed for less stringent control of variables and helped reveal causal relationships. A one-group pretest-posttest design was used for this study. A one-group pretest-posttest is a research activity in which a test is given first (pre-test) before treatment and (post-test) after treatment (Campbell, 1963). This type of research was carried out on only one randomly selected group.

The research instruments used were a pre-test, a post-test, and a questionnaire. The creative thinking ability test used in this study consisted of various description-based questions designed to measure students' creative thinking levels. The questionnaire used in this study is an ESD attitude questionnaire with indicators of the principles of maintaining environmental culture.

The research subjects involved were 36 students from SMA Negeri 3 Pemalang. Due to the greater diversity among the students compared to the other three classes, class XI.3 was selected as the research subject.

The data collection technique used was a test in the form of a pre-test, post-test and ESD attitude questionnaire. This pre-test and post-test on creative thinking skills were measured through written tests in the form of description questions developed from four indicators of creative thinking skills: flexibility, originality, fluency and elaboration. Each indicator has two questions, so the questions from the creative thinking ability questions are eight description questions, and each question is rated 0-10 with their respective criteria.

N gain is calculated using equation 1 (Hake, 1999).

$$N\ Gain = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \dots (1)$$

where S_{pre} is the pre-test score, S_{post} is the post-test score, and S_{maks} is the maximal score. The effectiveness criteria of N Gain are shown in Table 1 (Meltzer, 2002).

Table 1 Effectiveness score criteria of N-Gain

Score	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

Then, using the presentation to calculate the ESD attitude questionnaire. Five answers are available on the ESD attitude questionnaire in the study, including D (Disagree), SD (Strongly Disagree), U (Undecided), A (Agree), and SA (Strongly Agree).

RESULT AND DISCUSSION

The results of quantitative data analysis were collected using instruments such as pre-tests, post-tests, and questionnaires. The pre-test and post-test results can be used to assess how well the students' creative thinking abilities are tested. Table 2 shows that the N-Gain test results show that students' innovative thinking skills have improved significantly. The N-Gain test calculation shows that the STEM method improves students' creative thinking skills.

Table 2 N-Gain test results

	Average	Criteria
Gain Score	0.81	High
Gain Score (%)	81.87	Effective

Based on the N-Gain test results, students' creative thinking skills have increased significantly. This study identified four specific indicators of students' creative thinking skills, as shown in Table 3.

Table 3 Average indicators of test results for each indicator of students' creative thinking ability

Creative Thinking Ability Indicator	Average Value
Fluency Thinking	8.7
Flexibility Thinking	8.8

Creative Thinking Ability Indicator	Average Value
Original Thinking	9
Elaboration	8

Table 4 Student pre-test and post-test results

Category	Percentage
Very Creative	25
Creative	7
Quite Creative	3
Less Creative	1
Very Less Creative	0

The results of the pre-test and post-test data on students' creative thinking skills are presented in Table 4. It can be seen that very creative students are more dominant than other students.

The results of the research related to students' responses to the ESD attitude questionnaire on the principle indicator of protecting the environment can be seen from the percentage in the ESD attitude questionnaire shown in Table 5. The percentage of the ESD attitude questionnaire is in the very good category of 53%, the good category of 47%, the good enough category of 0%, and the poor category of 0%, so the data shows that the ESD attitude questionnaire effectively uses the STEM approach with ESD content.

Table 5 ESD attitude percentage categories

Range of Percentage	Category	Percentage
81-100	Very Good	53
61-80	Good	47
41-60	Good Enough	0
21-40	Poor	0
0-20	Very Poor	0

STEM (Science et al.) learning needs to be implemented into the school curriculum, especially in senior high school, to increase students' interest in STEM. According to Singgih (2020), STEM learning is used as an alternative

learning method because it trains students to apply their knowledge to create problem-solving designs that are relevant to the environment using technology. STEM approaches often include project-based learning, which can be an effective tool for teaching ESD concepts. Students can strengthen their understanding of the importance of sustainable behaviour by participating in projects that solve real-world problems and design sustainable solutions.

According to Keane & Keane (2016), STEM learning is a means to develop students' creative thinking skills. The challenge in the engineering process of design is to create a product design as a solution to a particular problem, and this learning is in line with the concept of creativity. One way to recognize and nurture students' creative potential and inspire students to take action based on that feedback is in a design-based learning framework (Hathcock et al., 2015). Simply put, creative thinking is the capacity of students to produce or discover something valuable in the world (Nurjanah & Cahyana, 2021). Creative thinking skills and student creativity have different meanings; creativity is the result of students' creative thinking. For this reason, teachers need a learning design that can realize students' creative potential, considering that creative thinking skills are a key element that needs to be achieved in the 21st century and the selection of effective learning strategies that foster students' creative potential. According to Bozkurt Altan & Tan (2021), the important awareness of the learning environment accentuates students' creative potential; a flexible learning environment is needed to allow students to direct learning, explore knowledge inside and outside the classroom, and release students from pressure.

Education for sustainable development, or ESD, teaches students to accept cultural diversity while making

responsible decisions and taking appropriate actions to protect the environment, economic viability, and a just society for present and future generations. The goal of ESD, Kalsoom & Khanam (2017) is to help students gain a deeper awareness of sustainability issues and modify their attitudes and actions towards sustainability in relation to social, economic, and environmental challenges. ESD highlights the phases of information transfer, attitude modification, and behaviour modification. Through action practices and critical reflection, policy change, and implementation, education for sustainable development creates knowledge (Wijayanti et al., 2021). However, it is now known that STEM education is the best type to use when introducing ESD programs into the classroom. Students are encouraged to participate in problem-solving activities by the pedagogical tenets of STEM learning, which align with the principles of ESD (Firda et al., 2021; Martín-Sánchez et al., 2022; Widarti & Roshayanti, 2021).

The results showed that students have high creative thinking skills in the STEM approach with ESD content and can fulfil flexible thinking, fluent thinking, original thinking and elaboration. Creative thinking has the highest average value of 90 points among the four indicators of students' creative thinking ability. The STEM approach incorporating ESD is suitable for use in schools because it allows students to think in new or unique ways. This approach can encourage students to practice creativity and sustainability awareness by integrating the three dimensions of ESD (social, economic, and environmental). Students can also design and create products to solve problems. STEM allows students to combine science, technology, art, and math learning activities to increase student interest in physics lessons.

Based on the data obtained, students' ESD attitudes better understand the concept of ESD sustainability and the integration of ESD values in physics learning covered in the three pillars of the ESD perspective (social, economic, and environmental). There is a need to integrate ESD into physics learning so that students can become aware of and sensitive to their environment. This regard has a huge scope for implementation (Rahmawati et al., 2021). According to Timm & Barth, (2021), teachers integrate ESD into learning by connecting through relevant content and appropriate methods. The role of teachers in driving learning changes in schools: teachers are a key element in the success of student learning by creating a meaningful learning environment and student learning outcomes.

Through the STEM approach with ESD content, students not only gain knowledge about sustainable issues but can also develop a positive attitude towards sustainability. Students are increasingly concerned about the environment, society and the economy and feel responsible for bringing about positive change. The use of STEM approaches enhanced with ESD in secondary schools has significantly improved students' ESD attitudes and creative thinking skills. Integrating ESD into the STEM approach can improve the quality of education by providing interdisciplinary learning that gives students authentic experiences (Abdurrahman et al., 2023); Gamage et al., 2022; Margot et al., 2019; Martín-Sánchez et al., 2022). Through this approach, education provides changes that encourage students to become critical thinkers, innovative, creative, and responsible for future global challenges. Therefore, incorporating ESD into STEM learning in high school will prepare students to achieve academic

success and become global citizens who contribute to sustainable development.

CONCLUSION

Based on the results of the study, it can be concluded that the STEM approach with ESD content is effective for improving students' attitudes, especially ESD attitudes and students' creative thinking skills, as evidenced by the N-Gain test score, which obtained a value of 0.81 with high criteria, and ESD attitudes are also categorized as very good, as seen from the percentage obtained, which is 53%, and for the good category obtained a percentage of 47%, so that the STEM approach with ESD content can be used as an alternative in physics learning. This is because there is an increase in creative thinking skills and ESD attitudes in students. This increase can develop creativity and a new idea for students, encourage students to be more responsible for sustainable issues, and emphasize curriculum development that supports the STEM approach, ESD, and students' creative thinking skills in other subjects. This research shows that the STEM approach with ESD content can improve students' creative thinking skills, creating an interactive and immersive learning experience for students. In addition, it can utilize emerging technologies as learning media and in the development of science by presenting a new perspective in education that focuses on sustainability and creativity.

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