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Supporting Students' Problem Solving Skills Using Science, Technology, Religion, Art, and Mathematics (STREAM) Approach on Sound Wave Concept

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Abstract: This study aims to investigate the effect of using science, technology, religion, engineering, art, and mathematics (STREAM) approach on students' problem-solving skills. The study was carried out in physics subjects, especially sound waves. Sixty high school students from one of the senior high schools in Tangerang Province, Indonesia, were divided into two groups to participate in a quasi-experimental study. Each group completed a particular learning sequence in sound wave topics where students in the experimental class carried out learning with the STREAM approach by following the engineering design process while students in the control class used conventional learning. Students' problem-solving skills were measured by eight essay questions. The study revealed that the STREAM approach had a significant effect on students' problem-solving skills ($p<0.05$). Students' problem-solving skill score in the experimental class was higher than the students' score in the control class. In addition, based on the comparison of the N-Gain values, the increase in the problem-solving skills of the experimental group was higher than that of the control group. The researchers conclude that STREAM is an effective teaching approach that science teachers might also incorporate in their classrooms.

Keywords: Engineering design Process; Problem-solving skills; STREAM; STEM education; Sound waves

Introduction

Sound waves are one of the topics of physics whose phenomena are often encountered in everyday life. Therefore, the explanations given by students are strongly influenced by that students' experiences (Chantaranima & Yuenyong, 2014; Farlow, Vega, Loverude, & Christensen, 2019). However, previous studies showed that students still often have difficulty understanding concepts (Hrepic, Zollman, & Rebello, 2010), including solving problems related to sound waves (Siahaan et al., 2018).

Problem-solving skills are one of the important skill for students. According to Sujarwanto et al. (2014), problem-solving skills is a complex cognitive activity in which there is a process of obtaining and organizing information in the form of a knowledge structure. If students are trained in thinking patterns and problem-solving abilities in learning activities, they will form a better mentality in solving problems and be braver in facing challenges (Cahyani & Setyawati, 2016). Finally, students can have the ability to understand a concept to be able to make the right decisions (Dai et al., 2019; Lin & Chiu, 2004). Nevertheless, several studies show that efforts to improve students' problem-solving abilities are still a challenge.

The issue of students' skills to solve problems in physics is also an area that continues to be studied. as the aforementioned explanation, one of the physics concepts where students' problem-solving abilities are

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still in the low category is sound waves (Eshach & Schwartz, 2006; Pejuan, Bohigas, Jaén, & Periago, 2012; Sözen & Bolat, 2011). A study conducted by Yana et al. (2019) showed that the understanding of sound waves topics was only 38% smaller than that of mechanical waves in water (50%) and mechanical waves on ropes (42%). The problem-solving skills that will be used in this study is the problem-solving skills according to Heller which consist of five stages, namely: understanding the problem, describing the problem in physics concepts, planning solutions, implementing solutions, and evaluating solutions (Heller, Keith, & Anderson, 1992).

Several attempts have been made to develop students' problem-solving skills in physics. The study conducted by Purwaningsih et al. (2020) showed that Science, Technology, Engineering, and Mathematics-Project based Learning (STEM-PJBL) can develop students' problem-solving skills on impulse and momentum materials. In line with these findings, Awad (2021) also found that STEM learning was effective in developing students' problem-solving in physics. By integrating several disciplines, the interdisciplinary approach is able to develop problem-solving skills because it provides a learning experience by connecting students' knowledge with real-world problems through project creation (Chen, 2019; Endang Purwaningsih et al., 2020; Shahali et al., 2017). Learning with an interdisciplinary approach allows students to get interesting learning experiences with real-world situations with various perspectives of disciplines. Although STEM interdisciplinary learning has shown its effect on students' problem-solving abilities, the involvement of religion and art aspects is still not widely disclosed.

STREAM is an interdisciplinary approach that incorporates STEM with Religion and Art. This approach can be an alternative to developing students' skills to solve problems. Furthermore, the addition of artistic aspects makes students free to be creative in learning activities (Shatunova et al., 2019). According to Land (2013), a person has the skills to learn through visual, auditory, and kinesthetic. The more learning experiences that involve several nerves, the brain will be stronger in remembering and understanding the given learning concepts. The art aspect of learning allows students to explore a concept from a different point of view, this may allow for better learning outcomes (Land, 2013).

In STREAM learning, religion is also an integrated discipline. The religious aspect complements learning in accordance with the goals of national education, namely to create a generation that is knowledgeable, responsible, and has noble character (Azizah et al., 2019). In addition, in this study, the schools involved are religious-based schools. Research conducted by Rahmawati et al. (2019) showed that the STEAM approach is able to develop students' logical reasoning in linking physics concepts with contextual problems to find the right solution to the given problem. This study aims to explore the effect of the STREAM approach on students' problem-solving skills on sound wave topics and how to improve students' problem-solving skills at each stage after applying the STREAM approach to learning.

Method

This study is a quasi-experimental design with a nonequivalent control group design (Sugiyono, 2017). The quasi-experimental method is an experimental research method that has a control group, but cannot fully control other variables (Creswell, 2012). The participants involved in this study were eleventh grade students at one of the Madrasah Aliyah Negeri in Kota Tangerang. Madrasah Aliyah is a school that is equivalent to a high school. In Indonesia, this type of school is shaded by the ministry of religion so that students get some additional lessons related to Islam. Sixty students were involved in the study where there were 30 students in the experimental class and 30 students in the control class.

In the experimental class, the STREAM approach with the engineering design process (EDP) model was implemented. According to Dare, Ring-Whalen, and Roehrig (2019), STREAM implementation through EDP is a learning activity that focuses on engineering design activities as a process for students to learn science and mathematics using technology. The stages of learning with the EDP model consist of define the problem, research, imagine, plan, create, test and evaluate, redesign, and communicate (Jolly, 2017). Meanwhile, in the control class, the learning is applied as conventional learning.

The instrument used in this study is a problem-solving instrument that consists of eight essay questions. The stages of problem-solving skills used are according to Heller et al. (1992), consist of understanding the problem, describing the problem in physics concepts, planning solutions, implementing solutions, and evaluating solutions (Heller et al., 1992). The instrument was validated by an expert and then tested on 30 students in order to obtain a Cronbach alpha reliability value of 0.909. This instrument was given before treatment (pretest) and after treatment (posttest).

Analysis of pretest-posttest data in the experimental and control groups using independent t-test and N-gain. The category of increased value based on the N-gain value can be seen in Table 1.

Table 1. N-Gain Score Category (Hake, 1998)

N-Gain Score	Category
N-gain ≥ 0.7	High
0.7 > N-gain ≥ 0.3	Medium
N-gain < 0.3	Low

Result and Discussion

The results of the pretest of problem-solving abilities in the experimental group and the control group before being given treatment can be seen in Table 2.

Table 2. Pre and Post-Test Scores of Students in the Two Classes within Each Condition

Group	Pre-test		Post-test	
	Mean	SD	Mean	SD
Control Class	29.10	12.97	43.00	12.05
Experimental Class	23.00	10.99	61.13	13.24

Table 2 shows that the average problem-solving skills of students in both classes increased after being given treatment. The average problem-solving skills of students in both groups were low before being given treatment, namely 29.10 and 23.00 for the control and experimental classes, respectively. After being given treatment, the increase in the problem-solving score of the experimental class was greater than that of the control class where the scores for both were 61.13 and 43.00, respectively.

Before treatment, the results of the pre-test showed that there was no difference in the average problem-solving skills in the control and experimental classes (t=1.965; p>0.05). After the treatment, the difference between the problem-solving skills of the experimental class and the control class was statistically observed from the results of the post-test t-test scores and the calculation of N-gain. The results of the t-test and calculation of N-gain in both groups can be seen in Table 3.

Table 3. Summary of Independet T-test for Post-test Score and N-gain

Group	t	df	P	N-Gain	Category
Control Class	-5.548	58	0.000	0.16	Low
Experiment Class				0.41	Medium

Table 3 shows that there is a significant difference between the experimental class and the control class (t=-5.548; p<0.05). Furthermore, the data also shows that there is a difference in the mean N-gain scores of the control group and the experimental group. The increase in the problem-solving skills of the experimental group was higher than that of the control group. The experimental group got an N-gain value of 0.41 which means that the problem-solving ability of sound wave material is in the medium category. Meanwhile, the control group got an N-gain value of 0.16, which means that the increase in problem-solving skills on sound wave material is in a low category.

The improvement of problem-solving skills of each stage can be seen in Figure 1.

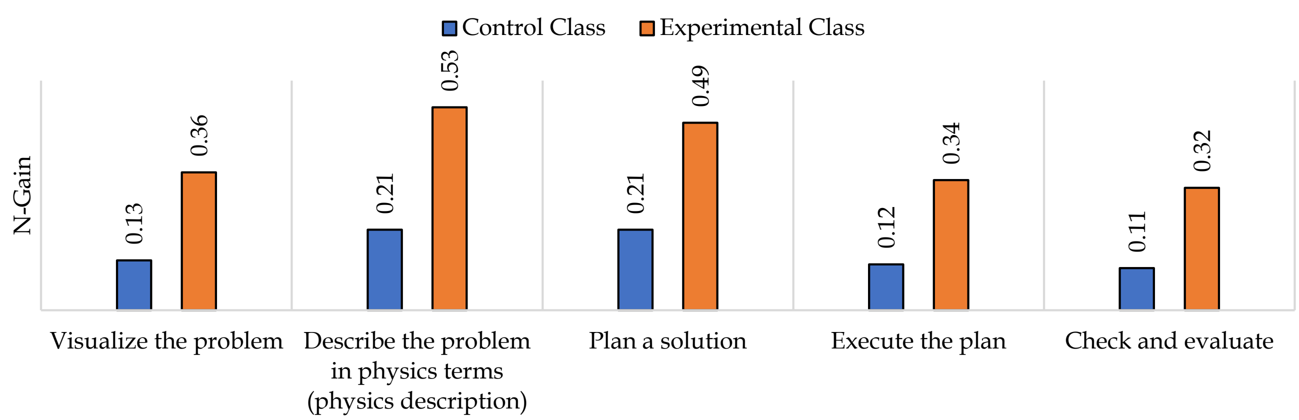

Figure 1. Comparison of the N-gain scores of the experimental class and the control class in the five stages of problem-solving

Figure 1 shows that the increase in problem-solving skills in the experimental class is higher than in the control class in all aspects. Both classes show the same pattern where the highest increase in problem-solving abilities occurs at the stage of "describe the problem in physics terms" wherein in the experimental class the average N-score obtained is 0.53 (medium category) while in the control class it is 0.21 (category). low). Meanwhile, the smallest problem-solving skills is obtained at the "check and evaluate" stage wherein the experimental class the average N-gain is 0.32 (medium category) and in the control class is 0.11 (low category).

This study aims to determine the effect of STREAM learning on students' problem-solving abilities. The results showed that STREAM learning had a significant effect on students' problem-solving skills. This research complements existing theories regarding the influence of interdisciplinary learning that is able to develop students' thinking skills. This study is in line with previous studies which have shown that interdisciplinary learning can improve students' problem-solving abilities (Asigigan & Samur, 2021; Awad, 2021; Malcok & Ceylan, 2021; E Purwaningsih et al., 2020; Yalçın & Erden, 2021).

STREAM learning makes students actively participate in learning and think about solutions to a problem. The increase in problem-solving skills at the stage of understanding the problem of the experimental group was obtained by 0.36 (medium category) and the control class obtained by 0.13 (low category). In the define the problem stage, students are trained to understand the problem of a text by restating the core problem in the given text.

The increase in the stages of describing problems in the physics concept of the experimental group was also superior with an increase of 0.53 (medium category). Meanwhile, the control class only got an increase of 0.21 (low category). This happens because in research activities that include aspects of science, technology, and religion, the experimental class is trained to seek information independently and discuss so that they can relate the problem to the concept of physics. In addition, students are also introduced to the relationship between science and religion by observing the verses of Allah's Kauniyah. This activity forms a better mastery of concepts and students are able to construct their knowledge to solve problems (Wandari et al., 2018). Instilling religious values also makes students more aware of the relationship between science and religion and believes in the power of the Creator (Agustina et al., 2018).

The problem-solving skills at the stage of planning a solution obtained an increase in the experimental group of 0.49 (medium category) while the control class was 0.21 (low category). The increase in the experimental group is higher because the imagine and plan activities that contain engineering and art aspects train students to come up with solutions to problem-solving ideas and describe them in a simple project plan. The engineering aspect consists of preparing the right project plan to be used as a problem-solving solution. The implementation of engineering aspects will build communication between students through discussion activities so that they can develop problem-solving skills (Alatas & Yakin, 2021). The art aspect in the STREAM approach makes students more creative and able to propose better problem ideas (Rahmawati et al., 2019).

The improvement in the stage of implementing the solution of the experimental group was also superior with an increase of 0.34 (medium category) while the control class was 0.12 (low category). This is because the creation activity which contains aspects of art and mathematics trains students to apply physics concepts to simple projects that have been previously planned by considering the mathematical equations obtained in research activities. The STREAM approach is able to equip students' creativity in learning because the learning activities are carried out to provide opportunities for students to find solutions in explaining scientific phenomena and train students' abilities in developing appropriate problem-solving strategies (Agustina et al., 2015). The STREAM approach is also able to increase students' interest and motivation in learning (Safitri & Priyambodo, 2016).

Problem-solving skills at the stage of evaluating the solution obtained an increase of 0.32 (medium category) in the experimental class and 0.11 (low category) in the control class. The advantage of the experimental group at this stage is that in the test and evaluate activities that contain aspects of mathematics, students are trained to test the solutions that have been made and determine whether the solutions made are in accordance with the problems and physics concepts used. Based on the results of testing and evaluation, all groups have completed the project well so there is no need to redesign. Test and evaluate activities involve students in the process of processing information and data obtained in project activities, making students not only look for solutions but also evaluate them (Rahmawati et al., 2019).

The problem-solving skills of the experimental class students increased in learning with the STREAM approach. Learning with an interdisciplinary approach learns various concepts that are directly related to problems or phenomena in the real world, making students not only understand texts and mathematical equations but they are also able to connect abstract concepts to real applications. Learning that involves students actively can increase interest in learning and develop thinking skills (Andriani, 2020).

Integrating several disciplines is not an easy job, especially for religious disciplines. This is a limitation in this study where religious disciplines are integrated as reading and encouraging students to learn. In the future, the study can be continued by integrating the six disciplines more comprehensively. Nevertheless, the results of this study indicated that STREAM could be an alternative to reformative learning to improve students' competence

Conclusion

The STREAM approach, which integrates science, technology, religion, engineering, art, and mathematics, improves high school students' problem-solving skills more effectively than traditional methods, especially on the topic of sound waves. STREAM encourages active learning and offers practical problem-solving opportunities, making it a beneficial alternative for skill development.

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A.S., F.A., N.H writing-original draft preparation, result, discussion, methodology, conclusion; A.S and F.A analysis, proofreading, review, and editing.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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