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The Effectiveness of STEAM Learning Based on "Robotis" Projects to Improve Science Literacy of Elementary School Students

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Abstract: In the industrial revolution era, many jobs that humans could initially do turned out to be done by computers and machines. Learning in elementary schools should be carried out by integrating various disciplines, for example, through project-based STEAM learning. STEAM learning incorporates the contents of Science, Technology, Engineering, Art, and Mathematics. The STEAM project chosen for implementation is Robotis (Robot Tisu/Tissue Robot). This study aims to describe the STEAM learning design of the Robotis project and determine the effectiveness of project-based STEAM learning in improving science literacy skills. This research includes a quasi-experiment with a one-group pretest-posttest design. The study was conducted at SD A (one of the private schools in Surabaya) with an experimental class subject of 15 students and a control class subject of 13 students. The instruments used are validation sheets of teaching modules and science literacy tests. Data were analyzed using the n-gain test and the Mann Whitney U-Test. The results showed that STEAM learning design must integrate several disciplines (science, technology, engineering, art, mathematics) in one learning and be associated with real-world problems. The significance value is 0.00 < 0.05 so that it is interpreted that there is a difference between the two groups (H1 accepted) which means that STEAM learning in the experimental class provides different results between pre-test and post-test. So, it can be stated that STEAM learning is effective for improving students' science literacy skills.

Keywords: Elementary School Students; Project Based Learning; Science Literacy; STEAM learning

Introduction

The education system in Indonesia continues to change to global demands. The 21st-century challenges such as the mastery of communication competencies, collaboration, critical and creative thinking impact changing learning in schools. In the face of learning in the 21st century, a person has the necessary thinking skills (critical thinking, creative thinking, collaboration, communication), knowledge, and abilities of digital literacy, information literacy, media literacy, and mastering information and communication technology or ICT literacy (Van Laar et al, 2020). Starting in 2021, assessments in Indonesia have implemented a national evaluation consisting of a Minimum Competency Assessment that tests literacy and numeracy competencies, character surveys, and learning environment surveys. The hope is that students are accustomed to literacy and that these literacy skills can support other skills. This science literacy is necessary for learners at the elementary level since it is said that learners with high science literacy will be able to create and use scientific concepts to analyze, explain, be accompanied by relevant evidence, evaluate and communicate conclusions appropriately. This will undoubtedly support the holistic improvement of other skills.

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The Programme for International Student Assessment (PISA), initiated by the Organisation for Economic Co-operation and Development (OECD), assesses systems in various countries, including Indonesia, by evaluating literacy, science, and mathematics competencies. Unfortunately, until 2018 PISA results in Indonesia were still substandard. Based on PISA results in 2018, Indonesia was ranked 74 out of 79 countries with a score of 396 for science competence (OECD, 2019). Other data reports from the results of PISA analysis, especially on science literacy, are known that learners can correctly explain general scientific phenomena and can use such knowledge to identify and infer from data on simple cases (OECD, 2019). However, when viewed on the PISA science literacy assessment criteria, namely being able to explain phenomena scientifically, interpret data and evidence scientifically, and evaluate and design scientific investigations, the ability of students in Indonesia still has not achieved that. Based on the previously described, changes should also occur in learning by using models, methods, and approaches. Science literacy is closely related to the process of scientific discovery or scientific proof. Therefore, the teaching used is project-based learning or promblem based learning (Wijayanti et al, 2020). One of the project-based learning is the learning of STEAM (Science, Technology, Engineering, Art, Mathematics).

Several previous studies have described the advantages of STEM/STEAM learning, namely that 1) introduced as a method that can increase students' creativity (Rahmawati et al, 2019) (Nazifah & Asrizal, 2022) ; 2) develop creativity and self-efficacy (a person's belief in his ability to accomplish things) (Conradty & Bogner, 2020); 3) improves communication skills (Nazifah & Asrizal, 2022); 4) enhance critical thinking skills (Hasanah et al., 2021) (Nazifah & Asrizal, 2022) (Rahmawati et al, 2019); 5) improve students' science literacy (Adriyawati et al, 2020) (Arrohman et al., 2022) (Sutiani et al, 2021); 6) improve science process skills (Anekawati et al., 2021) (Mukaromah et al, 2022); 7) improve student learning outcomes (Badriyah et al., 2020) (Azhar et al, 2022); and 8) improve communication and teamwork competencies (Kang, 2019).

STEAM has already begun to be implemented in developed countries. STEAM learning is a process that allows learners to come up with solutions in the face of their everyday problems by integrating the disciplines of science, technology, engineering, art, and mathematics (Ozkan & Umdu Topsakal, 2021). STEAM will provide a meaningful learning experience for learners. It is evident that a person who learns with a STEAM approach is able to explore all of his or her skills, find information from a variety of sources, communicate with others or experts, and produce something of value in terms of utility and economics, and thus are the best candidates for the future workplace (McGunagle and Zizka, 2020). The essence of STEAM education lies in the ability of learners to design their ideas, and learning planning to guide learners to realize their beliefs is an essential factor.

Students' science literacy skills can be trained from elementary school age. Based on the results of the PISA report that has been outlined, students in Indonesia still need to be familiarized with science literacy. Science literacy is a determinant of the human development index, which is significantly influenced by the quality of education (Bröder et al, 2017). Science literacy is not just reading scientific topics but also understanding the content and determining solutions to the problems presented in the reading. Learning should accommodate students to be literate. Science literacy is an individual's scientific ability to use his knowledge in identifying issues, obtaining new knowledge, explaining scientific phenomena, and drawing conclusions based on evidence related to scientific issues (Sutiani et al, 2021).

Project-based STEAM learning can be used to accommodate students to be familiar with science literacy. Based on previous studies that have been previously described, it can be seen that STEAM can improve science literacy. The novelty presented in this study is the learning design and STEAM project applied. The STEAM project in this study is titled "Robotis," which is an acronym for "Robot Tissue". In this STEAM Robotis project, there is an integration of essential competencies in elementary schools, namely mathematics, science, and cultural arts. This study aims to describe the design of STEAM learning with the Robotis project and determine the effectiveness of STEAM learning based on the Robotis project in improving science literacy skills.

Method

This research was conducted at SD A (one of the private elementary schools in Surabaya). The approach used in this study is quantitative. The research design used in this study is quasi-experimental design research with a nonequivalent control group design research design. The quasi-experimental design- nonequivalent control group design is shown in Figure 1.

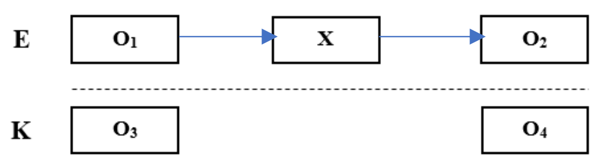

Figure 1. Quasi-experimental Research Design design- Nonequivalent Control Group Design

Information:
E = Experimental group
K = Control group
O1 = Students' science literacy ability before being given STEAM learning treatment (pretest) experimental group.
X = Treatment in practical classes in the form of STEAM learning.
O2 = Students' science literacy ability after being given STEAM (posttest) learning treatment in the experimental group.
O3 = Learner's science literacy ability before learning (pretest) control group.
O4 = Students' science literacy ability after learning (posttest) control group.

The steps in this study are 1) providing pretests in the experiment group and control group, 2) providing treatment in the form of implementing STEAM learning with Robotis projects in the experimental class, and 3) providing posttests in the experimental group and control group. The sample in this study was 28 sixth-grade elementary school students. This study's instruments are the teaching module's validation sheet and the science literacy test. The data analysis stages consist of 1) analyzing the validation results of the STEAM teaching module, 2) analyzing the effectiveness of STEAM learning in improving science literacy (normality test, n-gain, independent sample t-test if the data is usually distributed, and Mann Witney u-test if the data is not normally distributed).

Result and Discussion

STEAM *Learning Design*

The development of STEAM teaching modules begins with the analysis of Basic Competencies that can be integrated into one lesson. STEAM education in elementary schools integrates subjects such as science, mathematics, and the art. After that, mapping the STEAM components in the Robotis project is done. The STEAM components in the Robotics project can be seen in Table 1.

Table 1. The STEAM Components in the Robotis Project

Component	Description
Science	Explaining how to channel electrical energy, making robots with alternative sources of electrical energy (batteries), and stringing the flow of electric current.
Technology	Watch the creation video and browsing information about electrical energy
Engineering	Stringing cubes together into robot and installing the robot wheel
Arts	Decorate the robot
Mathematic	Create and merger a solid figure

The content of the student worksheet is learning instructions, learning objectives, presentation of fundamental problems related to the use of technology in the current era, and the results of student discussions of issues. In addition, student worksheet also contains student activities in designing tissue robots, including determining the procedure for doing projects. Furthermore, students answer questions related to the construction of space and its size, how the robot can move, and what energy changes occur.

Finding problems that suit the concepts, incorporating "engineering" into the project because the elementary school curriculum does not include "engineering" achievements, and the length of time required to create STEAM learning plans are all obstacles encountered when designing STEAM learning. STEM education ensures that students, through project-based learning, can apply the theoretical knowledge they learned in math, technology, and other natural science classes. It is often said that school-based math, engineering, and science education is not enough (Anisimova et al, 2020).

These challenges are also encountered by some researchers who design STEAM education, who cite time and the incorporation of engineering concepts as obstacles to planning STEAM education (Herro et al, 2019). Integrating creativity into the learning process is also essential. In this "Robotis" project, students are tasked with exercising their creativity by fashioning tissue robots in the form of unique characters. Change STEM to STEAM (Adding Art) in order to promote creativity (Conradty & Borner, 2018) (Conradty & Borner, 2020).

The results of the development of teaching modules (Learning Device Plan and Student Worksheet) are then validated by experts. Before testing in schools, teaching modules are subjected to validation to determine their practicability and the results are shown in Table 2.

Table 2. Teaching Module Validation Results

Aspects	Conclusion
Compatibility with Basic Competency	Very Valid
Display and language eligibility	Very Valid
Component fittings	Very Valid
Effectiveness	Valid
Display	Very Valid
Eligibility of Presentation	Very Valid
Effectiveness	Valid

The STEAM learning design developed is declared feasible and valid to use. This STEAM learning design is used for the 6th grade elementary school students in deepening their materials on spatial and electrical energy. This instructional design already incorporates elements of science literacy skills. Students are required to recognize scientific queries, identify evidence, draw conclusions, communicate conclusions, and demonstrate an understanding of scientific concepts as part of the aforementioned science literacy process (Arlis et al, 2020).

This study's STEAM learning design has the characteristics of scientific discovery or problem-solving investigation. The integration of STEAM education is an effort to integrate some or all of the four disciplines of science, technology, engineering, and mathematics into a singular unit or lesson based on the relationship between subjects and real-world problems. This is consistent with recommendations from previous research indicating that STEM education emphasizes on real problems and challenges students to be aware of the environment, the economy, and the problems near them, as well as to develop solutions (Agustina et al, 2019) (Stroud & Baines, 2019).

The use of technological devices to pursue information or supporting data pertinent to presented problems is one of the student activities. Utilizing engineering principles, students plan or design their invention or project. At the elementary school level, the use of technology is limited to searching for information using computers and digital platforms.

STEAM *Learning Effectiveness*

Furthermore, learning was carried out in two groups: the control and experimental groups. The control group was not given the treatment of STEAM learning implementation. To determine the effectiveness of STEAM learning in the experimental class, an n-gain test was carried out. The results of the n-gain test of the two classes are shown in Table 3.

Table 3. Pre-test and Post-test n-gain Calculation Results

Classes	N	Mean (n-gain)	Criteria
Experimental Class	15	0.523	Moderate Gain
Control Class	13	0.189	Low Gain

Based on Table 3, it can be seen that the n-gain of the experimental class is at a moderate criterion, meaning that there is a difference in the pretest and posttest scores of the experimental class. While the control class is at a low criterion, which means there is no difference in the pretest and posttest scores of the control class. To further show the difference and effectiveness of STEAM learning, an independent sample t-test is carried out if both data are distributed normally.

The normality test results show that the n-gain significance value in the control class based on the SPSS analysis is 0 (which means below 0.05), and the n-gain significance value in the experimental class is 0.2 (which means above 0.05). The conclusion is that the data is not commonly distorted. Therefore, the Mann-Whitney U Test is needed. The results of the Mann-Whitney U Test are shown in Table 4.

Table 4. Mann Whitney U Test Result

Class	Mean Rank	U Score (Mann Whit-ney)	W Score (Wilco-xon)	Z Score	Sig.
Experi-ment Class	19.77	18.5	109.5	-3.645	0.00
Control Class	8.42				

Based on Table 4, the mean rank of the experiment class differs considerably from the mean rank of the control class. Then it can be known that there are quite significant differences between the two groups. In addition, it can be known that the significance value is 0.00 which is below 0.05, so it is interpreted that there is a difference between the two groups (H1 is accepted). This means that STEAM learning in experimental class gives different results between pretest and posttest. Meanwhile, in the control class, the learning does not provide different results in students' pretests and posttests. This means that STEAM learning is effective for improving students' science literacy skills. This finding expands on previous research suggesting that STEAM can enhance science literacy through reading valid literature or information, connecting concepts, and drawing conclusions about problem-solving strategies (Adriyawati et al, 2020; Arrohman et al., 2022; Sutiani et al, 2021).

When working on their projects, students seek out as much science-related information as possible. This is when students employ their science literacy skills. In order for the students' science literacy test results to improve. According to previous research, a student's science literacy is indicated when he or she is able to recognize the significance of science in explaining commonplace phenomena (Adriyawati et al, 2020).

During STEAM learning, students appear enthusiastic, and there is no discernible difference between male and female students' interests. Observations indicate that female students also contributed to the "Robotis" initiative, despite the fact that robots are identical to male work. Recommendations for further research concern the influence of gender on thinking skills in STEAM education. Students have benefited from more constructive and interactive learning through the use of robots (Barnes et al, 2020). Robotics has the potential to help close the gender gap in STEM by increasing girls' interest in STEM careers and their perceptions of their own abilities (Barnes et al, 2020).

Conclusion

Based on the results of data analysis and discussion, it can be concluded that STEAM learning design must integrate several disciplines (science, technology, engineering, art, mathematics) in one learning and be associated with real-world problems.The significance value is 0.00 (<0.05), so it is interpreted that there is a difference between the two groups (H1 accepted) which means that STEAM learning in the experimental class gives different results between the pretest and posttest and it can be stated that STEAM learning is effective for improving students' science literacy skills.

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Author Contribution
Nadia Lutfi Choirunnisa conceptualized the research idea, designed of methodology, analyzed data, writing—original draft preparation, writing—review and editing. Suryanti management and coordination responsibility the research. Desi Rahmawati and Mulyani conducted a research and investigation process, collected data, and literature review. All authors read and approved the final version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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