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Experiential Learning with STEM-Computational Thinking (STEM-CT) Approach to Develop Students' Problem Solving Skills

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Abstract: Future challenges for learning require students to not only master concepts, but also develop thinking skills, one of which is problem solving skills. The aim of this study was to identify the effect of Experiential Learning with STEM-Computational thinking (STEM-CT) approach on students' problem solving skills. This research falls under a quasy experiment type with pretest-posttest control group design involving 60 students in 11th grade, especially on static fluid topic. The author collected quantitative data through pre-test and post-test, to assess the difference in students' problem solving skills between the experimental and control groups. Data analysis was carried out using parametric statistics, namely independent sample t-test, and obtained sig. 2 tailed of 0.001 which meets $p < 0.05$, so it can be concluded that there are differences in problem solving skills between the control class and the experimental class, after being given different treatments. The average N-Gain scores of the experimental class is also higher than control class. It indicates the effect of experiential learning with STEM-CT approach on students' problem solving skills. In the future, more in-depth research is needed related to the effect of experiential learning on various other thinking skills, especially in physics learning.

Keywords: Experiential learning; Problem solving skills; STEM-CT.

Introduction

The improvement of students' problem solving skills has become a focus of nowadays' education. The changing needs for worker competencies required in the 21st century make these skills necessary for higher education graduates (Atik et al., 2023). Along with the growing importance of mastering problem-solving skills, educators, researchers, as well as policy makers, also need to strive to identify and develop appropriate measures to deal with this new world of work (Saleem et al., 2024). The complexity of demands in society and the shift in various aspects of life that have been based on technology, urges the implementation of an education system that can prioritize the improvement of students' problem-solving skills (Roshid & Haider, 2024).

In contrast to the importance of problem solving skills for students, several studies have shown low mastery of these skills, especially in static fluid material. The results from previous researches show low scores of problem solving skills where students are still classified as novice solvers, especially on the topic of static fluid consisting of hydrostatic pressure, Pascal's law, and Archimedes' law (Bura et al., 2024; Estianinur et al., 2020; Ringo et al., 2019). Students in this novice category show difficulty in interpreting mathematical concepts and equations, so they tend to lead to incorrect solutions (Docktor & Mestre, 2014).

There are research that has been done before to improve students' problem solving skills. Some of them are by implementing the Project Based Learning model (Aprinaldi et al., 2023; Jalinus & Azis Nabawi, 2017) and guided inquiry (Palajukan et al., 2021; Utami et al., 2019). However, students tend to experience difficulties in

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solving problems due to lack of readiness and initial concepts (Tain et al., 2023), or due to abstract problems (Ismet et al., 2020). Based on this, an alternative solution to the existing problems is needed.

Experiential learning with the Science, Technology, Engineering, and Mathematics-Computational Thinking (STEM-CT) approach can be an alternative solution to minimize students' difficulties in solving problems. Experiential learning is a learning strategy that bridges the process of knowledge construction and how that knowledge will be used (Kong, 2021). Experiential learning actively involves students in the classroom, supports the reflection process, and develops and applies insight in the problem-solving process (Hulaikah et al., 2020). Furthermore, learning is needed that focuses not only on science concepts, but also supports the use of technology and engineering in contextual problem solving (Lestari, 2020). The STEM-CT approach integrates aspects of computational thinking (CT) into Science, Technology, Engineering, and Mathematics (STEM) practices where students are supported to solve complex problems (Supriyadi & Taban, 2024).

Although some studies have investigated the effect of experiential learning and STEM-CT separately, there are still few studies related to the effect of experiential learning with STEM-CT approach, especially with regard to its effect on students' problem solving skills. Previous results also recommend further research related to integrating STEM-CT in learning (Wang et al., 2022). Based on this, the study aims to investigate the effect of Experiential learning with STEM-CT approach on students' problem solving skills.

Method

This research is included in quantitative research, which is a quasi experiment with the research design that used is control group pretest-posttest design, as shown in Figure 1. This study consisted of two groups with different treatments, namely the experimental group and the control group. At the beginning, both groups conducted a pretest to determine the initial problem solving skills of students in each group. Furthermore, different treatments were given to the two groups. The experimental group was the class whose learning applied experiential learning and STEM-CT approach. As a comparison, the control class applied conventional learning. Then a posttest was conducted to determine students' problem solving skills after being given different treatments. The research was conducted involving 60 students in 11th grade or Phase F, which were divided into 34 male students and 26 female students. The sample members came from public high schools in Malang Regency, where the sample selection was carried out using random cluster sampling. There were 31 students in the experimental groups, and 29 students in the control groups.

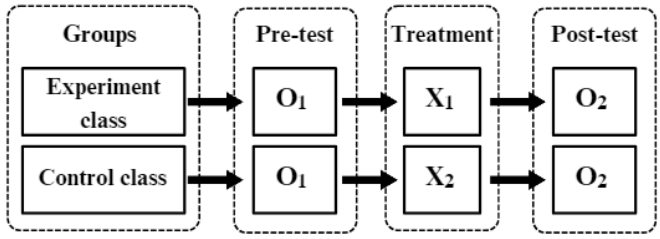

Figure 1. Research Design

Description:
O1 : Pre-test (before treatment)
O2 : Post-test (after treatment)
X1 : Treatment in experimental class (Experiential Learning with STEM-CT Approach)
X2 : Treatment in control class (conventional)

The type of data collected is quantitative data, namely pretest and posttest results that represent students' problem solving skills before and after different treatment. The measurement instrument used was 4 essay questions on the static fluid sub-topic, namely hydrostatic pressure, Pascal's law, and Archimedes' Law. The instruments were prepared according to the indicators of problem solving skills that refer to (Çalışkan et al., 2010; Çalışkan et al., 2010; Selçuk et al., 2008). The indicators consist of: (1) Understanding the problem, (2) Qualitative Analyzing, (3) Solution planning, (4) Applying the solution plan, (5) Checking.

The instrument used has gone through two validations processes, namely expert and empirical validation. Expert validation was conducted by two physics learning practitioners at the university level. The results of the empirical test of the instrument are shown in Table 1.

Table 1. Problem Solving Skills Instrument

Subtopic	Item Number	Poir Biseri Correlatio	Differenc Powe	Reliability
Hydrostatic Pressure	1	0.697	0.524	0.761
Pascal's Law	2	0.827	0.669	
Archimedes'	3	0.734	0.505	
Law	4	0.803	0.576	

Furthermore, the problem-solving skills scores were grouped according to the categories developed by Jua et al., (2018) shown in Table 2.

Table 2. The Interval Category of Students' Problem Solving Skills

Interval	Category
$94.25 < X < 100.00$	Very high
$79.75 < X \leq 94.25$	High
$65.25 < X \leq 79.75$	Sufficient
$50.75 < X \leq 65.25$	Low
$X \leq 50.75$	Very Low

Based on the categories that was developed, there are several characteristics of students according to the level of their problem solving skills. Students with a very low category of problem solving skills tend to have difficulty in understanding the problem, identifying variables, and re-evaluating the solution steps that have been taken. Students in the low category also tend to have difficulty in understanding the problem and rechecking the problem solving process. Students in the sufficient category tend to have difficulty in applying the problem solving steps that have been planned. In the high category, students can understand the problem and plan the solution process, although they tend to refer to quantitative solutions. Students in the very high category, have mastered the problem solving process.

Data analysis was conducted using parametric statistics. Previously, normality and homogeneity tests were carried out as the part of prerequisite tests. After ensuring that data from pretest results were normally distributed and homogeneous, an equality test of initial problem solving skills was conducted using an independent sample t-test on the pre-test data from both classes. The purpose of this analysis is to determine the comparison of initial skills possessed by students in the experimental group and control group. Subsequently, an analysis was conducted using parametric statistic, that is an independent sample t-test to determine the difference between the two classes after being given different treatments.After that, N-Gain analysis was used to identify the improvement in each group.

Result and Discussion

Table 3 shows the results of normality and homogeneity tests on the pre-test and post-test data of both classes. In the normality test using Shapiro-wilk, it is known that the results of both tests in the experimental and control groups are normally distributed ($p > 0.05$). The Lavene test to determine the homogeneity of the data of the two classes showed that both had homogeneous variances.

Table 3. The Prerequisite Test of Pre-test and Post-test Data

Test type	Groups	N	Mean	Sig. normality test	Sig. homogeneity test
Prior problem solving skills	Experimental	29	15.68	0.345	0.955
	Control	31	13.00	0.438	
Final problem solving skills	Experimental	29	35.61	0.065	0.937
	Control	31	25.21	0.085	

Given that the prerequisite test obtained normal and homogeneous results, then the next analysis proceeded with parametric tests. The results of the independent t-test related to the equality of prior problem solving skills showed a sig. 2 tailed value of 0.096. Based on the results where $p > 0.05$, it can be stated that the initial skills of students in the experimental and control groups has no difference. Post-test data analysis shows the results of sig. 2 tailed of 0.001. Based on the value of $p < 0.05$, it is known that there are differences in problem solving skills between the control groups and the experimental group, after being given different treatments. This is in line with the average N-Gain scores of the experimental class which is higher than the control class. The average N-Gain score of the control group who obtained $G_{ave} = 0.26$ was included in the low category, while for the experimental group with $G_{ave} = 0.44$ was included in the medium category.

The percentage diagram of the comparison of problem solving skills in each category in the experimental and control classes after being given different treatments is presented in Figure 2.

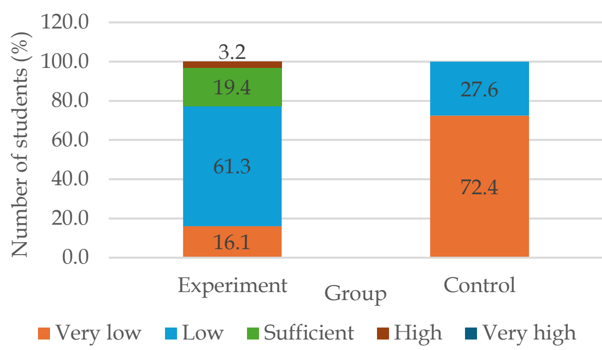

Figure 2. Number of students on problem solving skills category

Figure 1 shows a comparison of the percentage of students who fall into each category of problem solving. Based on the pre-test data, all samples of both experimental and control classes are still classified in the very low category. After being treated, although the experimental class was dominated by students in the low level, there was a general improvement compared to the initial data. Furthermore, the results from the control class showed dominance in the very low category, although as many as 27.6% had improved to the low category.

Figure 3 below shows the difference in average scores between the control and experimental groups, based on each indicator of problem solving skills.

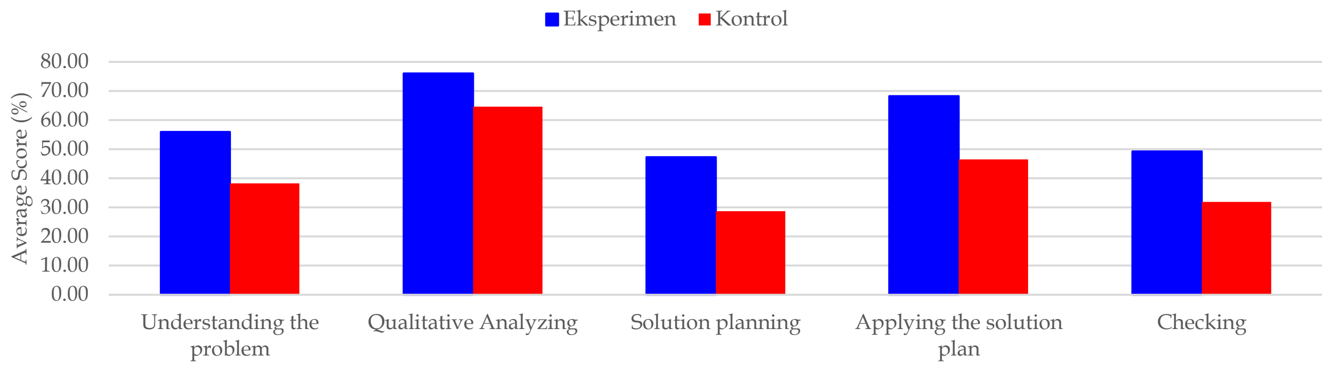

Figure 3. Problem Solving Skills on Each Indicators

Figure 2 shows that in all indicators of problem solving skills, the experimental groups has a higher average score when compared to the control groups. It shows the difference of results in the Experiential Learning class with the STEM-CT approach compared to the control class, on static fluid material.

The results obtained based on data analysis show a significant average difference between the problem solving skills possessed by the experimental group and the control group. The number of students in the experimental group who can be categorized in a higher skill level than before, indicates the effect of Experiential Learning with the STEM-CT approach on their problem solving skills. These results are in line with research showing that experiential learning can increase the role of students in obtaining meaningful knowledge, while directly involving in learning based on contextual problems (Villarroel et al., 2020).

Although the STEM approach is positively correlated with the improvement of various skills from various previous studies (Fiteriani et al., 2021; Hayuana et al., 2023), there are some difficulties and challenges in its implementation in learning. The complex characteristics of STEM become a difficulty for students who do not master the STEM domain, and cause students to lose motivation to learn (Margot & Kettler, 2019). Furthermore, the STEM approach, which trains students to face authentic problems, requires integrative knowledge in various STEM fields according to the context of the problem (Suhirman & Prayogi, 2023), which is often a challenge for students. Another difficulty is also related to the lack of basic STEM knowledge and limited quality materials (Ammar et al., 2024).

The integration of CT in STEM as an implemented approach plays a role in improving students' problem-solving skills. STEM-CT is seen as a strategy in incorporating aspects of computational thinking into learning practices that aims to equip students with the skills needed to solve real-world complex problems (Supriyadi & Taban, 2024). Abstraction and decomposition as one of the components of CT (Gong et al., 2020), can assist students in solving difficult problems by breaking them down into smaller parts that are simpler to solve.

One of the indicators with the lowest percentage score is on solution planning. It shows the difficulty of students in planning problem solving, including making indicators to make decisions on the solution of the problem. The results obtained are also supported by previous research which identifies common difficulties in problem solving, namely understanding the core of the problem solving process, and adjusting it to existing conditions (Istiyono et al., 2019). This difficulty can also be influenced by students' habit of following the solution steps in the book, instead of thinking deeply about the right solution steps (Gao et al., 2024).

In contrast, the indicators that show higher average scores of problem solving skills are qualitative analyzing and applying the solution. These two indicators relate to students' ability to select physics concepts that underlie problem solving, and mathematical procedures. It means that students can solve the problem quantitatively, but have difficulty in interpreting the results and applying them in solving the problem. Students' difficulty in stating this solution is indicated by the low average score on the checking indicator. The low score of students in the checking indicator is in line with the results of previous research (Henukh et al., 2024). This result also indicates students' difficulty in representing one form of information and connecting it with another form (Jannah et al., 2022).

The implementation of experiential learning generally involves a cycle where students gather knowledge through direct experience, construct it into a more formal form, and apply it to different cases. One form of application is to solve problems, where STEM aspects are emphasized in the process of making designs and products. This is in line with integrating CT with STEM learning which has the potential to improve science learning outcomes and increase student engagement through scientific inquiry and problem solving (Yang et al., 2018). This scientific investigation is expected to support the development of problem solving skills, which is a necessary skill in finding information and analyzing data (Ayunda et al., 2024).

We recognize some limitations in the research that has been conducted. Some of them are related to the small number of samples, as well as the need for more in-depth analysis related to factors that can affect the low scores on some of these indicators. In the future, further research is needed to identify the effect of Experiential Learning with STEM-CT approach on various other thinking skills, such as critical thinking skills and scientific reasoning skills. Further research can also be conducted by involving a larger sample size.

Conclusion

Based on the discussion before, it can be concluded that there is a difference in the average problem solving skills scores of students from the experimental group and control group. This is in line with the average N-Gain scores of the experimental class that is higher than the control class. It shows the effect of Experiential Learning with STEM-CT approach on students' problem solving skills. The results also show students' difficulties in determining problem solving steps and the basis for decision making in problem solutions. Further research is needed to determine the effect of Experiential Learning with STEM-CT Approach on other thinking skills.

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Conflicts of Interest
The authors declare no conflict of interest.

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