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The effectiveness of student worksheets based on computational thinking to the problem-solving skills of elementary school students in science learning

Arifah Rohmah. ✉, Universitas Negeri Yogyakarta
Sekar Purbarini Kawuryan, Universitas Negeri Yogyakarta

✉ *arifahrohmah.2022@student.uny.ac.id*

Abstract: This study aims to determine the effectiveness of student worksheets based on computational thinking in science learning on the problem-solving skills of fourth-grade elementary school students. The type of research used is a quasi-experiment, namely by using an experimental group and a control group. The experimental group is a class that uses student worksheets based on computational thinking, while the control group is a class that does not use student worksheet-based computational thinking. The sampling technique used was purposive sampling with a sample of 40 students. Data collection was carrying by giving a pretest and posttest containing several problem-solving ability questions. Data analysis was carrying by using descriptive and inferential statistical analysis. The results showed that, compared to the control groups whom did not use a student worksheets based on computational thinking, there was an increase in average test scores for higher problem-solving skills among experimental students. In addition, the results of the t-test also showed a significant difference in problem-solving ability between classes that used student worksheet-based computational thinking and classes that did not use student worksheet-based computational thinking. Thus, it concluded that student worksheet-based computational thinking is effectively able to improve the problem-solving skills of elementary school students in science learning.

Keywords: student worksheets, computational thinking, science learning

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INTRODUCTION

The world has now entered the 21st century, which is characterized by the rapid development of technology, information, and communication (ICT), allowing countries to connect with each other as if shrinking the world into a village (Malik, 2018). The rapid development of ICT needs to be balanced with an increase in the quality of human resources (HR) in order to survive and even play an active role in global competition. Efforts to improve the quality of human resources can be done through the transformative role of education that is able to equip students with various skills that are relevant to the needs of the times (Suyitno, 2020).

The skills needed in the 21st century and need to be used as a reference in the education and learning process in schools include: communication, collaboration, critical thinking and problem solving, as well as creativity and innovation (Samsudi, Supraptono, Sunyoto, & Rohman, 2019). Based on the four aspects of 21st century skills, one of the crucial skills to be improved is problem solving. It was consistent with the fact that the results of the program for international student assessment (PISA) test in 2018 are still constant, which places Indonesia 74th out of 79 countries in the world with scores in reading, math, and science that are still below average (OECD, 2019a). Furthermore, an analysis of the PISA test shows that Indonesian students who reach level 2 to level 4 in science are only 40% and a gap of 38% below the average ideal percentage set (OECD, 2019b). Therefore, it can be assumed that Indonesian students' problem-solving skills in the field of science or natural science (IPA) are still relatively low and need to be improved.

Science is a field of knowledge that explains natural phenomena and is very close to everyday life. Therefore science learning cannot be separated from problem solving skills. In other words, it can be explained that science learning continues to provide and equip students with the skills needed to solve the problems that exist around them (Daniel, 2016). In line with this view, other experts explain that problem-solving skills in science learning can be taught to students through the use of scientific processes to find solutions (Sukontawaree, Poonputta, & Prasitnok, 2022). Incorporating computational thinking into science education is essential for enhancing students' problem-solving abilities, leading to improved analytical skills.

Broadly speaking, computational thinking is a thought process of formulating problems and producing effective solutions (Grover & Pea, 2018). This statement is in line with the definition of problem-solving, which is the ability to identify obtained information, find solutions by connecting previous knowledge with existing knowledge, and implement solutions to follow up on problems (Cheng, She, & Huang, 2018). Referring to this definition, the integration of computational thinking in science learning is in line with improving problem solving skills. The integration of computational thinking in science learning is in accordance with the mandate of the independent curriculum explained by the Center for Curriculum and Learning Team, the Education Standards, Curriculum and Assessment Agency that one of the characteristics of the independent curriculum for elementary school level is integrating computational thinking into mathematics, Indonesian language, and IPAS (Natural and Social Sciences) subjects (Nurani, Anggraini, Misiyanto, & Mulia, 2022).

The integration of computational thinking in science learning, which is currently part of the IPAS subject, can be implemented by the teacher in the form of student worksheets. This is because student worksheets plays a role in supporting and facilitating the implementation of learning to help students understand the material (Rahayuningsih, Mustaji, & Subroto, 2018; Umbaryanti, 2016). In addition, LKPD can even be used as a guide to improve students' self-efficacy (Putri & Ranu, 2019). Even so, in reality, the existing student worksheets in schools is cannot ideally support the implementation of learning and even to improve students' problem-solving skills. It is corroborated by data from the school, which show that the student worksheets that are spread in the market and are widely used by schools show more material with exercises that are memorizing concepts so the role of student worksheets to develop problem-solving skills is less than optimal. Furthermore, this is exacerbated by the fact that many teachers only buy and use student worksheets without making adjustments according to student needs (Prastowo, 2013). That way, the student worksheets has not been able to answer the needs and characteristics of students.

Based on the explanation above, it can be inferred that teachers should develop the problem-solving abilities of elementary school students, particularly in science subjects, during the learning process. One way to achieve this is through the use of student worksheets based on computational thinking. The student worksheets based on computational thinking used in this study encompasses learning activities integrated with the four main foundations of CT, including: 1) Decomposition, which involves solving problems by breaking them down into smaller components; 2) Abstraction, which includes selecting which information about objects to ignore and which to store; 3) Pattern recognition, which entails paying attention to regularities, trends, and patterns in data; and 4) Algorithm, which involves designing a series of stages to solve problems (Tabesh, 2017; Yılmaz, Yılmaz, & Durak, 2017).

The use of student worksheets based on computational thinking to improve students' problem-solving skills has been based on several considerations, including: 1) Student worksheets based on computational thinking contain a number of activities in the form of challenges that require completing activities, so that science learning is not limited to memorizing concepts; and 2) Student worksheets based on computational thinking contain varied activities and are not limited to just drill practice questions, so that learning with the concept of problem-solving can take place more enjoyably.

Several studies have examined the use of student worksheets based on computational thinking. As stated on previous research (Mubharokh, Hapizah, & Susanti, 2023; Rahmania & Sulisworo, 2023), it is explained that the use of student worksheets based on computational thinking can make students able to write what is known from the problem, able to find patterns and connect them, and to determine the right solution procedure. Furthermore, the use of student worksheets also has implications for improving students' critical thinking skills. In addition, similar research (Bharata, Sutiarso, Noer, & Kurniawati, 2022) shows that the use of student worksheets based on computational thinking in learning can improve students' reversible thinking skills in math learning. Reversible thinking is one of the indicators that students need to have in problem-solving. Reviewing the research, this study comes with a novelty, specifically in the variables utilized, the field examined, specifically science, and the target subject, specifically aimed at the elementary school level. For this reason, the purpose of this study is to analyze the effectiveness of student worksheets based on computational thinking in improving the problem-solving skills of elementary school students.

METHODS

Research Design

This research uses a quantitative approach with a quasi-experimental design. This quasi-experimental design is use to see the causal relationship between the independent variable, namely the student worksheets based on computational thinking, and the dependent variable, namely problem-solving skills, through the use of control class and experimental class to obtain strong evidence. The application of this quasi-experimental design is to administer a pretest (O_1) to the experimental class and control class. After that, learning practices were carried out by giving treatment (X) to the experimental class through student worksheets based on computational thinking, while the control class used student worksheets from printed publications. Subsequently, both the experimental class and the control class received a posttest (O_2). The results of the pretest and posttest were then used to determine the effectiveness of the use of student worksheets based on computational thinking in problem-solving skills. In a simplified form, the research method can be seen in Figure 1 below.

Participant

This research was conducted in a public elementary school in Yogyakarta Special Region Province, Indonesia. The school is located in a rural area with a relatively large number of students and each class consists of two class groups. The population used in this research were 40 fourth grade students. In this research there were intervention classes and non-intervention classes in which the sampling was carried out using purposive sampling. The details of the number of samples are 22 students as the experimental class (intervention class) and 18 students as the control class (non-intervention class). In detail, the demographic characteristics of students can be seen in table 1 below.

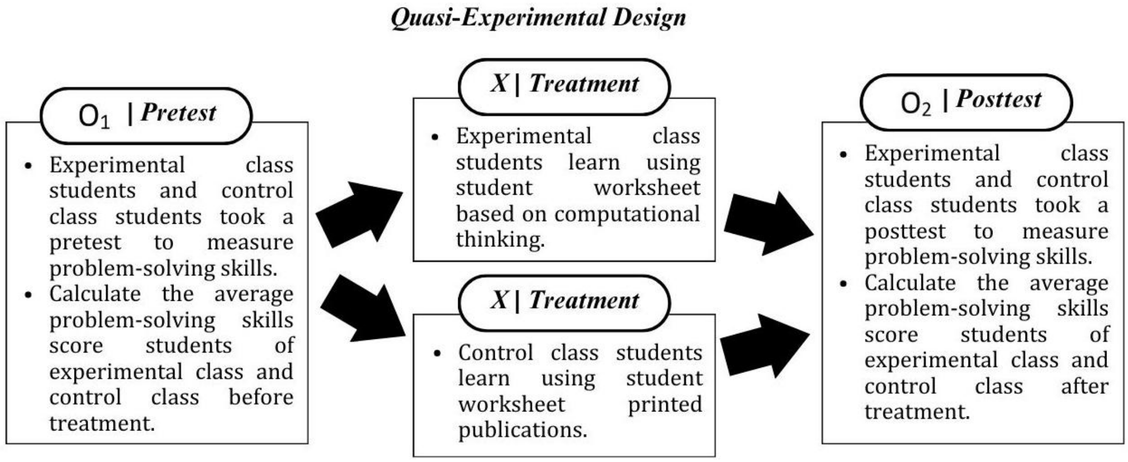

FIGURE 1. *Quasi-experimental research design*

TABLE 1. *Demographic characteristics of the students*

Demographic characteristics	Experimental Class	Control Class
Gender	Male : 12 (55%)	Male : 10 (56%)
	Female : 10 (45%)	Female : 8 (44%)
Age range	9-10 years	9-10 years
Cognitive ability	High : 4 (18%)	High : 3 (17%)
	Medium : 14 (64%)	Medium : 13 (72%)
	Low : 4 (18%)	Low : 2 (11%)

TABLE 2. *Details of problem-solving ability*

No	Indicators	Details
1	Identify ideas	Identify known conceptions that might help solve the problem.
2	State the explanation	Provide possible explanations for the problem.
3	Offer two potential fixes	Provide two possible solutions to solve the problem.
4	Evaluate solutions and choose the most practical one.	Evaluate their solutions and decide which one is the most applicable solution.
5	Interpret data and results	Provide an interpretation of the implemented solution.

Material

This experimental research uses pretest and posttest to measure students' problem-solving skills. For this reason, the type of instrument used is the form of a multiple-choice test. The problem-solving test instrument was prepared by referring to the five indicators of problem-solving ability, namely identify ideas, state the explanation, offer two potential fixes, evaluate solutions and choose the most practical one, and interpret data and results (Cheng, et al., 2018). Details for each aspect of problem-solving ability are as follows.

Before (pretest) and after (posttest) implementation of learning, students are given problem solving tests. The pretest aims to know the level of problem-solving skills that students already know, and is given before the implementation of learning. Meanwhile, the posttest is given after students complete learning with the aim of knowing the level of students' problem-solving skills for the learning that was conducted. The pretest and posttest instruments used in this study are the same. It aims to avoid the influence of instrument quality.

Procedure

The procedure in this research begins with conducting a preliminary study to obtain some introductory data related to problems that occur in schools by considering the level of urgency. After that, a literature study was conducted to examine the existing problem and continued through the preparation of research instruments. This research instrument is a testing instrument to measure students' problem-solving skills. The validated testing instrument was then used to conduct pretests and post-tests in the experimental and control classes. The data obtained from the pretest and post-test results were then tested for assumptions in the form of normality and homogeneity tests. The provisions of the assumption test are that if the data is declared normal and homogeneous, the analysis is continued with parametric statistical tests in the form of independent sample t-test and paired sample t-test to determine the significance value of the effectiveness of student worksheets based on computational thinking in science learning. This research procedure is then ended by drawing conclusions based on the analyzed research data.

Data Analysis

A series of data analyses was carried out in this study using the SPSS version 23 program. Data analysis begins with descriptive statistical techniques to analyze the average pretest and posttest results from experimental and control classes. The next step of data analysis is to conduct a prerequisite test in the form of a normality test and a homogeneity test. The normality test was carried out to ensure that the research data produced was normally distributed, namely with the provision of having a significance value ≥ 0.05 through the Kolmogorov-Smirnov calculation. Meanwhile, the homogeneity test was carried out to ensure that the groups being compared were homogeneous, namely with the provision of having a significance value ≥ 0.05 through the calculation of Levene's Test.

The normality and homogeneity test results, which declared normal, were then followed by parametric tests in the form of independent samples t-test (unpaired t-test) and paired samples t-test (paired t-test). The unpaired t-test used to analyze the differences in problem-solving skills of students in the control class and experimental class regarding their posttest scores. Data analysis using the unpaired t-test refers to the condition if the sig. If the p-value is less than 0.05, there is a difference in the average problem-solving ability between the experimental class and the control class. Otherwise, if the p-value is more than 0.05, there is no difference in the average problem-solving ability between the control class and the experimental class. Meanwhile, the paired t-test was conducted to analyze the differences in students' problem-solving skills in the experimental class in terms of the results of the pretest and posttest scores. Data analysis using paired t-test refers to the assumption that if the sig value. (2-tailed) < 0.05, then there is an effect of using computational thinking-based science LPD to improve students' problem-solving skills, and otherwise if the sig. If (2-tailed) > 0.05, then there is no effect of using student worksheets based on computational thinking in students' problem-solving skills.

RESULT

The results showed that the use of student worksheet based on computational thinking could improve the problem solving skills of fourth-grade primary school students. It can see from the results of the descriptive statistical test analysis, which shows an increase in the average pretest and posttest results for both the experimental and control classes. However, the average increase in the experimental class was much more significant than in the control class. Table 3 below shows the results of the descriptive statistical test analysis.

The data in table 3 shows that the average pretest scores of students' problem-solving skills in the experimental and control classes were 49.55 and 46.67, respectively. These results indicate that the problem-solving skills of the students in the experiment class and the control class before they have the treatment did not show a significant difference in the average. For the after-treatment, the experimental class used the student worksheets based on computational thinking and the control class used the student worksheets from print publications, both showed different average improvements. The posttest results of students' problem-solving skills for the experimental class were 75.00, indicating an average increase of 25.45 (51%). In contrast, the posttest results of students' problem-solving skills for the control class were 56.94 with an average increase of 10.27 (22%). Based on these average results, it can conclude that students who use student worksheets based on computational thinking show a more significant average increase compared to students who use student worksheets from print publications. The difference in mean for the pretest and posttest scores of the experimental class and the control class can be seen in figure 2. Meanwhile, the difference in mean gains for the experimental class and the control class can be seen in figure 3.

TABLE 3. *Statistics descriptive test*

Class	Type of Test	N	Minimum	Maximum	Mean	Std. Deviation
Eksperiment	Pretest	22	15	90	49.55	22.196
	Posttest	22	45	100	75.00	15.811
Control	Pretest	18	15	90	46.67	22.229
	Posttest	18	20	90	56.94	19.789

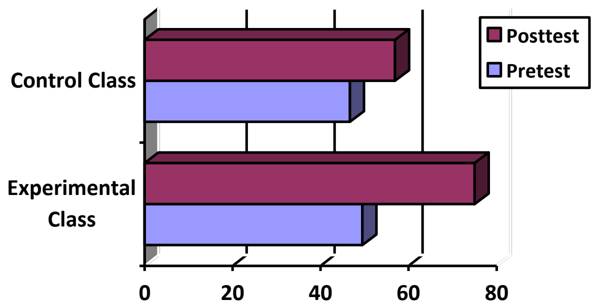

FIGURE 2. *The mean pretest and posttest difference of the experimental class and control class*

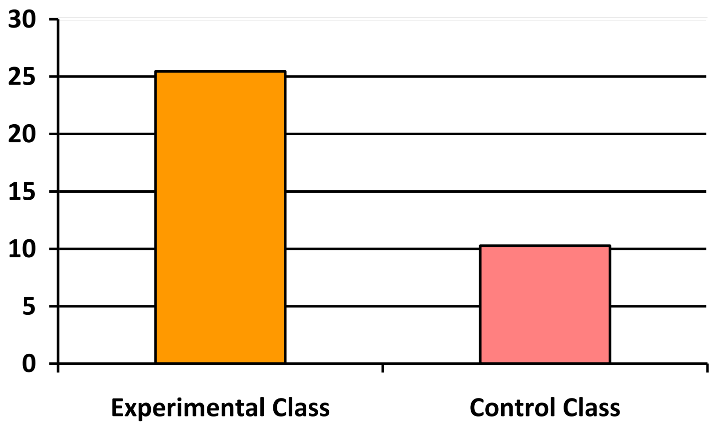

FIGURE 2. *The mean gains difference of the experimental class and control class*

TABLE 4. *Normality test*

Class	Type of Test	Kolmogorov-Smirnov[a]	*Explanation*
Eksperiment	Pretest	.200*	Normal
	Posttest	.200*	Normal
Control	Pretest	.200*	Normal
	Posttest	.200*	Normal

TABLE 5. *Homogenity test*

Levene Statistic	df1	df2	Sig.	Explanation
.741	1	38	.395	Homogen

The next stage of data analysis is to perform a prerequisite test, namely the normality test and the homogeneity test, to determine whether the data will be processed using parametric statistical tests or non-parametric statistical tests. The normality test was conducted using the Kolmogorov-Smirnov calculation, while the homogeneity test was carried out using the Levene statistic calculation. The results of the normality test and the homogeneity test can be seen in the table 4 and table 5.

In table 4, it can be explained that the normality test results of the pretest and posttest data of students' problem-solving skills in the experimental class and control class through the Kolmogorov-Smirnov calculation show the same significance value of 0.200. These results have exceeded the assumption value set at > 0.05, so all of the data can be declared normally distributed. Meanwhile, in table 5 it explained that the results of the homogeneity test for the pretest and posttest data of students' problem-solving skills in the experiment class and control class, through the calculation of Levene Statistic (based on the mean), show a significance value of 0.395. These results have exceeded the required assumption value of >0.05, indicating that all data comes from a homogeneous population. Therefore, it concluded that the research data meet the prerequisite test of normal distribution and homogeneity. Therefore, the data analysis was continued by performing parametric statistical tests.

The parametric statistical tests used in this study were the independent samples t-test and the paired samples t-test. The independent samples t-test was conducted using posttest data of students' problem-solving ability in experimental and control classes, while the paired samples t-test was conducted using pretest and posttest data of the experimental class. The results of the independent and paired samples t-test are presented in Tables 4 and 5, respectively.

TABLE 6. *Independent Samples t-test*

Variable	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Problem solving	.741	.395	3.209	38	.003	18.056	5.626

TABLE 7. *Paired Samples t-test*

	Description	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-25.455	13.532	2.885	-8.823	21	.000

Table 6 shows that the results of the independent samples t-test in the experimental class and control class, in terms of posttest scores, resulted in a sig. (2-tailed) of 0.03 (<0.05). These results explain that H0 is rejected and Ha is accepted. In other words, it can be concluded that there is a significant difference in problem-solving ability between the experimental class that uses computational thinking-based science LPD and the control class that uses printed LKPD. Meanwhile, based on table 7, it can be seen that the results of the paired samples t-test analysis using pretest and posttest data in the experimental class show a sig. (2-tailed) of 0.000 (<0.05). These results explain that H_0 is rejected and H_a is accepted. Thus, it concluded that there are differences in students' problem-solving abilities before and after using student worksheets based on computational thinking.

DISCUSSION

Student worksheets based on computational thinking are able to improve students' problem-solving skills by integrating the foundations of computational thinking, which include decomposition, pattern recognition, algorithm, and abstraction (Tabesh, 2017). The four foundations of computational thinking are in line with efforts to improve problem-solving skills, which are reviewed from several indicators, including identify ideas, state the explanation, offer two potential fixes, evaluate solutions and choose the most practical one, and interpret data and results (Cheng, et al., 2018).

The relationship between the foundations of computational thinking integrated in the LKPD IPA with indicators of problem-solving ability as a reference for measuring the improvement of these abilities can be explained as follows: 1) Including identify ideas is to focus on the most essential part of the problem (Veronica, Siswono, & Wiryanto, 2022), so it is in line with the foundation of decomposition (breaking the problem into smaller components) (Tabesh, 2017), 2) State the explanation and offer two potential fixes is one strategy in solving problems is to use previous experiences that have similar characteristics to the current problem (Fauziah & Setiawan, 2018), so that it is consistent with the foundation of pattern recognition (paying attention to the regularity of patterns in data) (Tabesh, 2017), 3) Evaluate solutions and choose the most practical one, namely carrying out problem-solving steps to develop students' creative thinking and problem-solving skills through the discussion method, so that this is in line with the foundation of the algorithm (a series of stages to solve problems), and 4) Interpret data and results, namely reanalyzing the problem-solving steps taken and being able to make general conclusions (Fauziah & Setiawan, 2018), so that this is in line with the foundation of abstraction (abstracting information that needs to be discarded and importance to keep) (Tabesh, 2017).

The implementation of computational thinking in science learning through student worksheets focuses on the water cycle material. In general, the problems that students asked to solve are related to the existence of land-use change events that have an impact on disrupting one of the stages of the water cycle. For this reason, the foundation of computational thinking in the student worksheets can be observed in more detail in the following explanation: 1) Decomposition is to describe the various problems that can be caused by the existence of land conversion events. 2) Abstraction is to infer the important role of trees from the existence of land conversion events related to the water cycle. 3) Pattern recognition is to recognize the sequence pattern of images of the occurrence of the water cycle based on the material that has been read. 4) Algorithm is to describe the stages of the water cycle. The effort to improve problem-solving skills through the implementation of student worksheets based on computational thinking is in line with the expert opinion that computational thinking can develop problem-solving skills (Ansori, 2020) and reasoning skills (Tsai, Shen, Tsai, & Chen, 2017).

In addition, the activities carried out by students through student worksheets based on computational thinking designed to involve active student roles in knowledge acquisition through questions and answers and group discussions. This method is implemented by the teacher to stimulate students' creativity in problem-solving (Afriansyah, Herman, Turmudi, & Dahlan, 2021). In line with this explanation, another opinion explains that the use of student worksheets based on computational thinking can lead students to solve existing problems through group discussion activities and answer problems related to everyday life (Marshel & Ratnawulan, 2020; Yuliani, Noer, & Rosidin, 2018; Yustina & Kapsin, 2017). Furthermore, the use of discussion methods in learning is able to involve students to carry out mental activities, namely thinking to solve problems in a conducive, more relaxed, and fun learning situation (Moma, 2017).

In terms of presentation, this student worksheets based on computational thinking based is displayed with variations such as relevant images and phenomena and packaged with the use of attractive color compositions so that the variety of content can attract students' attention to engage in the learning process (Yasir, Susantini, & Isnawati, 2013). In addition, the availability of instructional materials, in this case student worksheets, that are interesting and fun can also facilitate students' understanding of the learning materials (Nawawi & Kusnoto, 2019). In other words, students' understanding of learning materials is one of the essential assets for problem-solving. It is in line with the opinion of experts who explain that problem-solving skills can be possessed by students after understanding various knowledge and work skills (Winarso, 2014).

CONCLUSION

The results of this study indicate that the implementation of student worksheets based on computational thinking has a significant effect on the problem-solving skills of students in the fourth-grade of elementary school. This is evidence by an increase in the average test scores of higher problem-solving skills in experimental classes that use student worksheets based on computational thinking compared to control classes that do not use student worksheets based on computational thinking. In addition the results of the t-test also show a significant difference in problem-solving skills between classes that use student worksheets based on computational thinking and classes that do not use student worksheets based on computational thinking.

This research is expected to provide references for other researchers as well as a form of contribution to the development of science, especially in the field of science at the elementary school level. In addition, this study still has limitations in the variables used, which only measure problem solving ability. For this reason, further research is expected to test the effectiveness of student worksheets based on computational thinking on other variables.

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