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Do Computational Thinking and Self Regulated Learning Affect Computer Programming Problem Solving Skills? : An Experimental Study

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Abstract: This study aims to analyze the effect of computational thinking and self regulated learning on computer programming problem-solving skills. The research used a quasi-experiment with a factorial design. Research sampling using a purposive sampling technique. The sampling of this study used a purposive sampling technique, namely students of Bumigora University, Indonesia. The data collected were in the form of tests with data analysis techniques using inferential statistics. The results showed the fulfillment of the prerequisite tests of normality and homogeneity with each Sig value obtained > 0,05. The paired sample t-test test in the control and experimental groups obtained each Sig value < 0.05, so it can be concluded that there is a significant difference in student learning outcomes in each control group and experimental group. The independent sample t-test test obtained a Sig value < 0.05, so it can be concluded that there is a significant difference between the computational thinking method and the conventional learning method. The independent sample t-test test obtained a Sig value < 0.05, so it can be concluded that there is a significant difference between high and low self-regulated learning. Factorial ANOVA test obtained Sig value <0.05, so it can be concluded that the interaction between learning methods and self-regulated learning makes a significant difference in the ability to solve computer programming problems. The implications of applying computational thinking methods and developing self-regulated learning skills significantly improved problem-solving skills in computer programming, thus supporting the need to integrate this approach into curricula and teaching strategies.

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Introduction

Education in higher education is a form of planned effort to realize a learning atmosphere and an active learning process to develop student potential. Effective education must consider the learning process in accordance with the various learning styles of students (Amin et al., 2024; Elnour, 2022; Huang et al., 2024; Massouti et al., 2024; Mousavi et al., 2024; Pardamean et al., 2022) aims to overcome learning difficulties and achieve the full potential of students including in computer programming. Student learning difficulties in programming (Hasana et al., 2024; Malkoc et al., 2024; Simarmata et al., 2024; Tareq & Raja Yusof, 2024; W. Yan et al., 2024) due to factors, one of which is the lack of student ability to design mathematical models (Amidi & Khoirunnisa, 2024; Hartatiana et al., 2024; Muslimahayati et al., 2023; Susilawati & Sugilar, 2024; Zulmaulida & Saputra, 2023) so that it can be implemented into a programming language. This lack of ability in mathematical modeling stems from weak skills in mathematics. In addition, the method of learning mathematics in computer study programs should provide opportunities for mathematical modeling skills to support the improvement of student skills in designing computer programs (Ahsan et al., 2024; Fuadiyah et al., 2024; Mukushev et al., 2024; Supriadi et al., 2023; Takács et al., 2024; J. Yan, 2024). Therefore, it is necessary to adjust the programming language learning model with one of the computational thinking (CT) learning models.

Computational thinking (CT) is one of the skills that is the cornerstone of 21st-century learning (Alzahrani, 2020; Christensen & Lombardi, 2024; Ouyang & Xu, 2024; Rincon-Flores et al., 2024) Computational thinking has an important role in preparing students to face the increasingly complex and rapid digital era. Computational thinking is a basic skill that needs to be mastered to effectively and efficiently solve problems in the digital era. The application of CT requires a variety of cognitive abilities, including decomposition and abstraction, algorithms, pattern recognition, iterative thinking, transformation, problem reduction, error prevention and preservation, and intuitive reasoning (Akramova et al., 2024; Barricelli et al., 2024; Katuk et al., 2024) which are important in developing problem-solving skills. The ability to solve problems is also one of the assets in mastering computer programming (Bubnic et al., 2024; Gonçalves et al., 2024; Hijón-Neira et al., 2024; Zhang et al., 2024). Problem-solving ability is a high-order thinking skill (HOTS) (Affandy et al., 2024; Hamzah et al., 2024; Purnomo et al., 2024; Raza et al., 2024; Samadi et al., 2024). This ability is very important for learners in the digital era. Learning based on computational thinking to train learners to be skillful (Angraini et al., 2023; Y. Chen, Zhao, et al., 2024; Gökçe & Yenmez, 2023; Irwandani et al., 2023; Park & Jeon, 2022; Prasetyo & Pramudita, 2023) solve programming problems with the scientific basis of mathematics, especially on the subject of linear algebra.

Application of computational thinking in programming languages involving linear algebra (Y. Chen, Okyay, et al., 2024; Y. Chen, Sandhofer, et al., 2024; Luszczek et al., 2024) includes the use of concepts such as decomposition, pattern recognition, abstraction, and algorithm design to solve complex mathematical problems (Adanır et al., 2024; Lee et al., 2024; Lopez-Parra et al., 2023; Yadav & Chakraborty, 2023; Yanti et al., 2024). Computational thinking has a systematic framework for applying linear algebra in programming languages (Bratitsis et al., 2024; Lv et al., 2023; Pietros et al., 2023) as more effective and efficient problem-solving. Linear algebra has a role in programming languages (Schmitt et al., 2023; Tang, 2021), especially in scientific computing and data analysis. One of them is matrix and vector operations as the core of algorithms and numerical methods used to solve systems of linear equations, geometric transformations, and analyze data. Linear algebra in computer graphics (Jayakumar et al., 2024; Mittenbühler et al., 2024) is the foundation for the manipulation and transformation of three-dimensional objects. Objects in three-dimensional space can present vectors and various operations. Linear algebra can implement efficient and effective algorithms to improve the ability of accurate models (Krysl, 2024; Li et al., 2024; Yu et al., 2024). The ability of computational thinking that connects linear algebra in programming languages, needs an active individual approach to the learning process. One approach is self-regulated learning (SRL) (Fan & Wang, 2024; Feldman-Maggor et al., 2024; Namaziandost et al., 2024).

Self-regulated learning is an active individual approach to managing and directing the learning process that involves the ability to set goals, plan strategies, monitor progress, and evaluate learning outcomes independently (Rincon-Flores et al., 2024; Samadi et al., 2024). Self-regulated learning includes the components of intrinsic motivation, metacognition,

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management of time and resources (Chang et al., 2024; Jhunjhunwala et al., 2024; Pereles et al., 2024; Wu et al., 2024). Intrinsic motivation encourages students to learn according to their interests while metacognition involves awareness and control in the thinking process. Time and resource management ensures students can allocate time and effort effectively to achieve learning goals. Development of students' self-regulated learning skills (Balazinec et al., 2024; Findyartini et al., 2024; Nguyen, 2024) can increase independence, responsibility, and effectiveness in learning, and can improve academic achievement and deep understanding.

Several studies related to the effect of computational thinking on learning outcomes have been conducted (Abouelenein & Nagy Elmaadaway, 2023; Agbo et al., 2023; C.-Y. Chen et al., 2023; L. Cheng et al., 2023; S.-C. Cheng et al., 2024; Cırıt & Aydemir, 2023; Purwasih et al., 2024; Sukardi et al., 2024; Tikva & Tambouris, 2023). Research topic self regulated learning on learning outcomes (Faridi & Izadpanah, 2024; Follmer et al., 2024; Lei, 2024; Ma & She, 2024; Radović et al., 2024; Rameli et al., 2025; Rusmansyah et al., 2024). However, research that measures the effect of computational thinking and self-regulated learning on computer programming problem solving has not been found. Therefore, this study aims to analyze the effect computational thinking and self regulated learning on computer programming problem solving skills.

Research Method

The method of research used was a quasi experiment with a factorial design. The research sampling used a purposive sampling technique, namely students of Information Technology, Bumigora University, Mataram, West Nusa Tenggara. There were two classes involved, namely control and experimental classes. The instrument used for the collection was a test. The prerequisite tests used were normality test and homogeneity test. A normality test is conducted to determine whether the data is normally distributed or not. Homogeneity test to determine whether the data used has the same variety or not. The inferential statistical tests used were paired sample t-test, independent sample t-test, and factorial ANOVA test. The paired sample t-test test was conducted to determine the difference between the two paired samples. Paired samples are the same subject but experience different treatments. The independent sample t-test was conducted to determine the difference test of two unpaired samples. Factorial ANOVA test was conducted to determine the difference between two or more groups based on one characteristic.

Results and Discussion

The data in this research was in the form of student learning outcomes data that has been collected and then analyzed to determine the effect of computational thinking and self-regulated learning on problem solving skills in computer programming courses with linear algebra subject matter. Data on pretest student learning outcomes with computational methods obtained an average value of 22.56 and a standard deviation of 12.90. Posttest student learning outcomes with computational methods obtained an average value of 74.02 and a standard deviation of 19.47. While the pretest with conventional learning obtained an average value of 21.94 and a standard deviation of 17.59. Posttest student learning outcomes with conventional learning obtained an average value of 27.26 and a standard deviation of 18.39.

Before conducting inferential statistical tests, a prerequisite assumption test was carried out which includes normality and homogeneity tests. The normality test was carried out to determine whether the data was normally distributed or not. Homogeneity test to

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determine whether the data used has the same variation or not. The Kolmogorov-Smirnov test and Levene Test were used to ensure that the data met the requirements for normal distribution and homogeneity of variance before applying further statistical tests (Early et al., 2024; Godina & Matias, 2018; Kurt et al., 2024; Liu et al., 2018; Patrício et al., 2017). The results of the normality prerequisite test with the Kolmogorov-Smirnov test obtained a Sig. value of 0.245 > 0.05 so it can be concluded that the data distribution is normally distributed. The results of the homogeneity prerequisite test with the Levene Test obtained a Sig. value of 0.191 > 0.05 so it can be concluded that the data used has a homogeneous variety.

The effectiveness of computational thinking on student problem solving learning outcomes was carried out by pretest and posttest design with paired sample t-test and independent sample t-test analysis techniques. The paired sample t-test results in the control group obtained a Sig. value of 0.014 < 0.05, so it can be concluded that there is a significant difference between student learning outcomes in problem solving before conventional learning and after conventional learning. The paired sample t-test results in the experimental group obtained a Sig. value of 0.000 < 0.05, so it can be concluded that there is a significant difference between student learning outcomes in problem solving before the computational thinking method is carried out and after the computational thinking method. The results of the independent sample t-test test obtained a Sig. value of 0.000 < 0.05, so it can be concluded that there is a significant difference between the computational thinking method and conventional learning methods, where the computational thinking method group has a higher value of student learning outcomes in problem solving compared to the conventional learning method group.

The effectiveness of self-regulated learning on students' problem solving learning outcomes was carried out in an experimental design to determine the difference between high and low self-regulated learning with independent sample t-test analysis technique because it is assumed that high and low self-regulated learning are free or do not affect each other. The results of the independent sample t-test of self regulated learning can be seen in Table 1.

Table 1. Independent Sample T-Test of Self-Regulated Learning

Class	Self Regulated Learning	Mean	t	Sig.
Control	Low	15.00	-12.117	0.000
	High	49.55		
Experiment	Low	52.86	-8.119	0.000
	High	85.00		

Based on Table 1, the test results of the control group student problem solving learning outcomes variable show a Sig value of 0.000 < 0.05, so it can be concluded that there is a significant difference between self regulated learning, where high self regulated learning has higher student learning outcomes compared to low self regulated learning. The test results of the experimental group student problem solving learning outcomes variable show a Sig value of 0.000 < 0.05, so it can be concluded that there is a significant difference between self regulated learning, where high self regulated learning has a higher student learning outcome value compared to low self regulated learning.

The effectiveness of computational thinking and self-regulated learning on students' problem solving learning outcomes was carried out experimental design with factorial ANOVA test analysis technique to determine the difference between learning methods and self-regulated learning on students' problem solving ability. The results of factorial ANOVA analysis can be seen in Table 2.

Table 2. Factorial ANOVA Test Results

Tests of Between-Subjects Effects

Dependent Variable: HASIL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35440.890[a]	3	11813.630	24.767	.000
Intercept	155772.461	1	155772.461	326.570	.000
KELOMPOK	14064.244	1	14064.244	29.485	.000
SLR	5501.917	1	5501.917	11.535	.001
SLR * KELOMPOK	2198.251	1	2198.251	4.609	.036
Error	31004.762	65	476.996		
Total	270250.000	69			
Corrected Total	66445.652	68			

a. R Squared = .533 (Adjusted R Squared = .512)

Based on Table 2, it is obtained that learning methods and self-regulated learning each have differences in student learning outcomes in problem solving because they have a Sig value 0.000 < 0,05. The results of the interaction between learning methods and self-regulated learning have a significant difference because the Sig value is 0.036 < 0.05, so it can be concluded that there are individual factors of learning methods and self-regulated learning that make a significant difference to students' computer programming problem solving ability on the subject of linear algebra and the interaction between learning methods and self-regulated learning makes a significant difference to students' computer programming problem solving ability on the subject of linear algebra. The conceptual implication of this study is that the application of computational thinking and self-regulated learning significantly strengthens the theory about the effectiveness of these approaches in improving problem solving skills. Practically, the results emphasize the need for integration of computational thinking methods and self-regulated learning development strategies in the curriculum and teaching strategies, as well as adjustments to the assessment system to reflect the impact of the combination of the two approaches.

Conclusion

Based on the results of the study, it can be concluded that the learning outcomes on the pretest and posttest with computational thinking obtained an average of 22.25 and 74.05 respectively with a standard deviation of 12.90 and 19.47. Meanwhile, the pretest and posttest with conventional learning obtained an average of 21.94 and 27.26 respectively with a standard deviation of 17.59 and 18.39. Prerequisite tests of normality and homogeneity with each obtained Sig value 0.245 > 0.05 and 0.191 > 0.05. The paired sample t-test test in the control and experimental groups obtained a Sig value of 0.014 < 0.05 and 0.000 < 0.05, respectively, so it can be concluded that there is a significant difference in student learning outcomes in each control group and experimental group. Independent sample t-test test obtained Sig value of 0.000 < 0.05, so it can be concluded that there is a significant difference between the computational thinking method and the conventional learning method. The independent sample t-test test obtained a Sig value of 0.000 < 0.05, so it can be concluded that there is a significant difference between high and low self-regulated learning. Factorial ANOVA test obtained that the results of the interaction between learning methods and self-regulated learning have a significant difference because the Sig value of 0.036 < 0.05, so it can be concluded that the interaction between learning methods and self-regulated learning makes a significant difference to the ability to solve computer programming problems.

Recommendation

Recommendations for future research are the use of a more comprehensive experimental design by adding relevant variables. Furthermore, research can also be conducted on different population groups that are similar and broader. Then, the development of more valid and reliable instruments to measure problem-solving skills in the context of linear algebra. In addition, developing and adding interventions or learning strategies to improve the interaction between learning methods and self-regulated learning to maximize its positive effect on problem-solving ability.

For lecturers, it is recommended that they integrate the principles of computational thinking and the development of self-regulated learning skills in the curriculum and use teaching methods that combine these two approaches. For students, it is important to actively apply computational thinking principles and develop self-regulated learning skills through regular practice, time management techniques, and utilization of additional resources to improve their learning effectiveness.

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