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The Effect of Self-Directed Learning Through Mathematical Puzzle Media on the Learning Outcomes of Class II Students at SDN 02 Sriwangi

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Abstract:
This study aims to analyze the influence of the application of the model *Self-Directed Learning* (SDL) media-assisted *puzzle* mathematics on mathematics learning outcomes in the addition and subtraction of whole numbers material for second-grade students at SD Negeri 02 Sriwangi. Using a quantitative approach with a design*Pre-Experimenta l*shape *One-Group Pretest-Posttest Design*This study involved all 16 second-grade students using a saturated sampling technique. Data collection was conducted through an initial test (*pretest*) and final test (*posttest*). Data were analyzed using descriptive statistics, normality tests*Shapiro-Wilk*, as well as hypothesis testing*Paired Sample t-test*. The results of the descriptive analysis show an increase in the average class score of 18.12 points, from 64.69 at the first stage.*pretest*to 82.81 on*posttest*, as well as a jump in classical learning completion from 18.75% (3 students) to 93.75% (15 students). Inferential test results*Paired Sample t-test*generate value$t(15) = -9{,}966$with significance$p < 0{,}001$ $(0{,}000 < 0{,}05)$, which confirms the rejection$H_0$and acceptanceH_1. In addition, the effect size obtained (*Cohen's d*) of 2.49 indicates a very large treatment impact. Taking into account the limitations of a single-group design without a control group, the combination of SDL and media*puzzle*proven to be effective in improving the conceptual understanding of mathematics in lower grade students.

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Introduction (مقدمة)

Education is a key faktor in developing quality human resources. Through education, n addition to gaining academic insight, students guided in their character transformationof their

character, moral values, and the life skills necessary for living in society. Therefore, Consistent and continuous development of educational quality is necessary to adapt to changing times. Education also serves as a means to develop students' overall potential, including cognitive, affective, and psychomotor aspects (Abd Rahman et al., 2022).

Mathematics is a core subject that must be taught from elementary school to secondary school. Mathematics learning ams to enable student to understan and aply mathematical concepts in everyday life. Furthermore, mathematics Become the main pillar in advancement of science and technology good for various disciplines and as a field of study that develops independently (Astriyana et al., 2023). However, in the author's experience, mathematics is often considered a difficult subject for elementary schol student, in particular those in the lower grades. This condition is triggered by the characteristics of mathematical objects, which tend to be abstract. Therefore, In the lower grades of elementary school, children's cognitive abilities are still limited to concrete matters. A mismatch betwen the demands of the subject matter and this developmental phase of become a chalenge for students in master concepts, which in turn negatively impacts their academik achievemen. Lerning outcomes can be defined as the competencies acquired by learners after completing learning activities, with these achievements being subject to evaluation through various assessment techniques (Fidya et al., 2021). From an educational perspective, learning outcomes are used as a benchmark to measuring abilities in master the knowledg, skils, and attitudes acquired during teaching process (Winasih et al., 2023).

In fact, optimal learning outcomes are due to factors that influence learning outcomes, namely two factors, namely internal factors originating from within the student, such as a low level of interest and motivaton to learn, as wel as ekternal paktors stemming from the surrounding environment, for instance, the family conditions and the school environment.

In general, learning outcomes encompass three domains: knowledge, attitudes, and skills. In mathematics learning, the cognitive domain is the primary focus because it relates related to the abilty to understan concepts, recall facts, apply procedures, and solve problems all of which align with critical thinking skills based on Bloom's Taxonomy (Listiani & Rachmawati, (2022).

The suces of learning proces is, by nature, interactive, involving a mutual influence between teacher and student. That is how it should be, many schools still face the issue of low student learning outcomes, as indicated by the large the sum of students' scores below the Minimum Competency (KKM) (Sidmewa et al., 2021). This consistent with problem experienced by students at SD Negeri 02 Sriwangi, where initial observations showed that students' mathematics learning outcomes were still relatively low. The low mathematics learning outcomes were evident in daily assessments in mathematics lessons. Of the 16 students, half had not yet achieved the KKM set by the school. Furthermore, the mathematics learning process was still dominated by teachers with limited use of learming media, sch as whiteboards. Students tended to be passive, less involved in learning activities, and easily bored during the learning process. These conditions impacted student activity, independence, and low learning outcomes, especially in mathematics.

Data on mathemattics learning success of class II students at SDN 02 Sriwangi in the last five years (2021-2025) has tended to decline, namely58% (2021), 62% (2022), 55% (2023), 58%(2024), until it reaches its lowest point50%in 2025. This condition is triggered by

conventional learning practices which are still centered on teachers (*teacher-centered*), limited use of concrete media (only relying on the white bord), as well as minimal involvement and independence in student learning dring the lerning process.

Therefore, this condition results in unstable student learning outcomes, with many students still not achieving the Minimum Competency (KKM). Yet, learning outcomes are a crucial indicators for conducting an efaluation of the efectivenes of the learning process. Therefore, mathematics instruction in lower grades requires appropriate approaches, models, and learning media to enable a more concrete and meaningful understanding of mathematical concepts.

Self-Directed Learning (SDL) is a lerning model tht emphasies students' ability to take the initiative in planning, implementing, and evaluating their own learning process, both with and without the help of others (Sarahono et al. 2024). This model places students as the main subjects in learning and encourages them responsible for their own learning process (Izzatanur & Rachmadtullah, 2024). Furthermore, this learning can be done individually or with friends, thus still providing space for interaction in learning (Sidmewa et al., 2021). Self-Directed Learning emphasizes students' ability to manage their independent learning process. Trisiana (2023) states that Self-Directed Lerning is a larning process that encourages students to learn independently.

The implementaion of the Self-Directed Lerning model aims to foster students' learning independence, enabling them to seek information, solve problems, and adapt to various learning situations. In a basic context, the teacher remains a facilitator, providing direction and support to ensure the learning process continues according to established objectives (Loeng & Story, 2020). For optimal implementation of the Self-Directed Learning model, learning media appropriate to the characteristics of lower-grade students are required. Learning media play crucial role in helping to concretely understand abstract material, particularly in Mathematics (Bopo et al., 2023). One such learning medium is the Math puzzle. Math puzzles present addition and subtraction problems in the form of interactive visual puzzles. Through tactile-kinesthetic activities—such as calculating number operations, finding matching pieces, and arranging them to form a complete picture—this medium transforms abstract concepts into concrete experiences.

The use of puzzles enables student to engage active in lerning through play-while-learning activities, thereby increasing student interest and motivation, making the further learning process enjoyable and less boring (Indrawati & Fauzi, 2023). Puzzles also offer various benefits for child development, including sharpening thinking skills, developing hand-eye coordination, improving reading skills, practicing reasoning, and fostering patience (Istiqomah et al., 2026). aplication of puzzles in the mathematics classroom can be implemented through several steps. These steps include the teacher explaining the material, giving assignments using puzzles, and presenting the results. This process encourages students to be active and understand concepts more concretely, particularly in fractions (Novita et al., 2023). Therefore, math puzzles are an effective and functional learning tool for helping students grasp mathematical concepts, such as addition, more easily. Furthermore, using this tool can create an active and enjoyable learning environment (Indriani & Suriani, 2024).

The use of Mathematics puzzle media is in accordance with the principle of Self-Directed Learning because it provides oportunities for student to learn independently through the activity of trying, arranging, and finding their own answers. Thus, students not only receive information

from the teacher, but are also directly involved in implementing teaching and learning activities. This is expected to improve the activeness, independence, and acquisition of competencies by learners of Mathematics students in grade II. Several previous studie have demonstratd the eficacy of implement the Self-Directed Learning model. For example, research by Wulandari & Sari (2025) showed regarding the Self-Directed assisted Learning model form Wordwall media has a very strong influence on student learning outcomes in the subject of Science in grade IV elementary school. The focus of the research was on upper grade students using digital-based media in the form of Wordwall and applied to the subject of Science. However, this research has differences with the conditions that will be examined in this studi. Previous research was conducted on upper grade students using digital-based media in the form of Wordwall and applied to the subject of Science.

There are still limited literature and research gaps that test the integration of the SDL model assisted by physical manipulative media such as special mathematical puzzles to improving the learning outcomes of addition and subtraction of whole numbers in lower grade students (grade II of elementary school). Lower grade students have cognitive development characteristics and levels of independence that are significantly different from upper class students, thus requiring interactive physical media orientation and specific guidance. Threfore, the novelty of this researh lies in the aplication of the Self-Directed Learning model based on mathematical puzzle media to the learning achievement of mathematics subjects in grade II elementary school students. This studi aims to identifi the significance of diferences in mathemati learning outcomes before and after the aplication of the Self-Directed Learning model assisted by mathematical puzzles at SD Negeri 02 Sriwangi.

Method

This study used an ekperimental methd withh quantitative aproach. The research design used was a pre-experiment design with a one-grup prettest-posttest format. $(01 \longrightarrow X \longrightarrow 02)$. The poplation used in this stdy were all 16 second-grade students of SDN 02 Sriwangi. The samplingg technique used in this study was saturated sampling. The tretment intervention was carried out in 4 metings with a duration of 25-35 minutes per session on the addition and subtraction of whole numbers, Meeting 1 (Pretest), Meetings 2 & 3 (Application of SDL & Puzzle Media) and Meeting 4 (Posttest). The pretest was conducted to measure students', initial abilitiess before treatment The posttest was conducted to measure students' learning outcomes after treatment. Data collection techniques use in thiş study were observation, testing, and documentation. The analysis techniques used included descriptive statistical analysis, normality tests, and hypotesus testing

Result

The result of researc at SD Negeri 02 Sriwangi regarding the effect of implementing the Self-Directed Learning (SDL) a model supported for mathematical puzzle media on mathematics learning outcomes Prior and subsequent implementing the Self-Directed Learning model through mathematical puzzle media can be observed from descriptive statistical analysis, normality tests, and hypothesis tests.

Table 1 Comparison of Pretest and Posttest Values

Test Types	Number of Students	Rate-Rate
Pretest	16	64,69
Posttest	16	82,81
Improvement		18,12

Descriptive analysis is used to see the picture of the values before treatment and after treatment. Based on **Table 1**, from a total of 16 students, the average score*pretest*class is64.69with a classical learning completion percentage of18.75%(only 3 students achieved the KKM). After the intervention, the average score*posttest*increased to 82.81(average increase of18.12points), and classical learning completion increased drastically to93.75%(15 students completed)

The next step, once data collection is complete, is to test the analysis prerequisites by conducting a normality test. The data test is used to test whether the data being analyzed is normal. The data being tested for normality is the data from the data analysis.*pretest* And *posttest*students. Data normality analysis is conducted using method*Shapiro-Wilk*, because the sample size in this study was less than 50 people. The decision-making criteria were based on comparing the distribution data obtained at a significance level of 5%. If sig > 0.05, the data is normal distributed, and if sig < 0.05, the data does not meet the assumption of normality.

Table 2 Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Say.	Statistic	df	Say.
Pretest	.136	16	.200*	.950	16	.491
Posttest	.172	16	.200*	.912	16	.123

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on the results of the normalit test calculations *Shapiro-Wilk*above results obtained*pretest* students of 0.491 > 0.05 and the result *posttest* students of 0.123 > 0.05, Because both values are greater than 0.05, it is concluded that the pretest posttest value data are normally distributed. The nekt step is to tset the hypothesis using*paired sample test*which is useful to find out wether there are diferences in mathematics learning outcome before and after applying the Self-Directed Learning model through mathematics puzzle media for class II students at SDN 02 Sriwangi.

Table 3 Paired Sample Hypothesis Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-18.125	7.274	1.819	-22.001	-14.249	-9.966	15	.000

Based on the test results*Paired Sample t-test* above obtained The Sig.(2-tailed) value is 0,000 This value is smaler thn 0.05. (0.001 < 0.05), so it is in accordance with the testing criteria hypothesis, then H_0rejected H_1accepted. This means that there is significant effect of use the Self-Directed Learning model through mathematical puzzle about learning outcomes grade 2 students in the addition and subtraction of whole numbers.

Discussion

Research findings consistentli show that the aplication of the Independent Learning model through mathematical puzzle media has a significant positive influenc on the learning out comes of second-grade students at SDN 02 Sriwangi.This finding is supported by an increase in the achievement of descriptive indicators and inferential test results. Descriptively, students' initial abilities before the intervention (pretest) were still very low, characterized by a class average that only reached a score of 64.69 and a very minimal level of completion of 19%. This low pretest score indicates that the conventional learning methods or media used previously were less than optimal in facilitating students' mathematical understanding of addition and subtraction of whole numbers. However, after being given an intervention in the form of a Self-Directed Learning model assisted by mathematical puzzle media, students' academic performance experienced a significant jump. The average class score jumped to 82.81, which means a net increase of 18.12 points. Furthermore, the percentage of classical learning completion grew exponentially from 19% to 94%. This confirms that the tested learning model is effective in transforming students' previously incomplete understanding into complete understanding in meeting the KKM.

The success of improving learning outcomes is strongly supported by the test results.*Paired Sample t-test*which produces a significance probability value (Sig. 2-tailed) of 0.000. Because the Sig. value of 0.000 < 0.05, the statistical decision taken is to reject $H_0$and receive H_1. These theoretical and empirical facts confirm the real influence of the applied treatment on students' mathematical competence. Theoretically, the effectiveness of this intervention lies in the synergistic collaboration between the Self-Directed Learning model and the use of mathematical puzzle media. The Self-Directed Learning model encourages second-grade elementary school students to begin to be actively and independently involved in constructing their own understanding. This independence is strengthened by the presence of mathematical puzzle media as a concrete teaching aid. For students at the concrete operational stage (elementary school age), abstract visualizations regarding addition and subtraction operations of whole numbers become much easier to understand through the activity of arranging puzzle pieces. This

media transforms the atmosphere of mathematics learning, which is often considered rigid, into an interactive, challenging, and meaningful game activity. In general, a comparative comparison of all the data in this study indicates that the Self-Directed Learning model through mathematical puzzle media successfully provides a strong, adaptive positive effect, and is proven effective in an effort to optimize academic achievement through of second-grade students at SD Negeri 02 Sriwangi. The success and main mechanism of this intervention are based on Jean Piaget's Cognitive Development Theory, specifically regarding the Concrete Operational Stage. Piaget stated that children aged 7 to 11 years are not yet able to fully process abstract logical operations without the aid of concrete physical representations. Before the intervention was given, conventional learning dominated by teachers using abstract mathematical symbols on the blackboard created a cognitive mismatch with the developmental stage of second-grade students (aged 7–8 years), resulting in low student engagement and understanding. The results of this study strengthen and expand previous empirical findings. For example, research by Wulandari & Sari (2025) proved that the SDL model assisted by digital media*Wordwall*has a significant influence on the learning outcomes of fourth grade students in science. If their research focuses on higher grades with digital media, this research has succeeded in filling the research gap (*research gap*) by proving that SDL is also very effective for lower grade students when combined with concrete physical media such as*puzzle*Mathematics. This confirmed that success SDL model in elementary schools is highly dependent on the appropriate selection of media that is appropriate to the students' cognitive development stage.

Despite the positive findings obtained, this study has some limitatios that need to be overcome openly acknowledged. First, this studi used a descriptive design.*Pre-Experimental One-Group Pretest-Posttest*without a comparison control group. As a result, threats to internal validity—such as student maturation factors (*maturation*) or the influence of learning history (*history*)—cannot be completely eliminated. Second, the relatively limited number of samples ($N = 16$) from one school limits the level of generalizability of the findings broadly. Therefore, further research is recommended for use a cross-sectional design.*Quasi-Experimental* or *True Experimental*with matched control groups, a broader sample of multiple schools, and longitudinal observations to see long-term retention of understanding.

Conclusion

Base on the explanation, the conclusion this study are outlined below: The implementation of the Self-Directed Learning model through mathematical puzzle media has been proven to significantly improfe the mathematics learning outcomes of the adition and subtraction of whole numbers material for second-grade students of SDN 02 Sriwangi. This is show by a substantial average increase in the class score of 18.12 points, namely from 64.69 in pretest stage to 82.81 in posttest stage. This learning intervention succeeded in drastically increasing the students' learning completeness in a classical manner from 19% in the prettest to 94% in the post-test. The data shows a shift in the majority of students from the incomplete category to complete in meeting the Minimum Completeness Criteria (KKM). he results of the hipothesis test using Paired Sampel t-tes tshows a sig value (2-tailed) of 0,000 which is smaller than the specified significance level (a = 0.05). Thus, Ho rejected and Hi acsepted, which confirms empirically that there is a positive

and sigpificant influence of the use of the Self-Directed through puzzle media on student learning outcomes.

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