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The Effect of Picture and Number Patterns Student Activity Sheets Based on Bruner Theory on the Learning Outcomes in Grade IV Elementary School

Adin Amalia Nuril Asrori[1*], Dya Ayu Agustiana Putri[2], Muhammad Agus Avisina Alfarisy[3]
[1-2]Universitas Bhinneka PGRI, Indonesia, [3]Institut Al Kadi Al Fakih Abdallah Ben Said Al Oujdi, Morocco
**Corresponding author : adinamalia4123@gmail.com*

Abstract

Learning mathematics in elementary schools remains challenging because students often experience difficulties in understanding abstract concepts, particularly in picture and number pattern materials. Conventional teacher-centred instruction limits students' active engagement and conceptual understanding. This study aimed to determine the effect of Bruner-Based Theory Student Activity Sheets (SAS) on the learning outcomes of fourth-grade elementary school students in picture and number pattern learning. This study employed a quasi-experimental method using a nonequivalent control group design. The participants consisted of 88 elementary school students, including 46 students in the experimental group and 42 students in the control group. Data were collected through pretest and posttest learning outcome tests. The instrument was confirmed to be reliable (Cronbach's $\alpha = 0.981$) and valid through exploratory factor analysis. Data were analyzed using tests of normality, homogeneity, and an independent samples t-test with the assistance of Jamovi software. The results showed no significant difference between the experimental and control groups in the pretest ($t = -1.30$, $p = 0.201$), indicating comparable initial abilities. However, a significant difference was found in the posttest scores ($t = -5.82$, $p < 0.001$), with the experimental group outperforming the control group. These findings indicate that the implementation of Bruner-Based Theory Student Activity Sheets effectively improved students' learning outcomes by facilitating the transition from enactive and iconic representations to symbolic understanding. In conclusion, Bruner-Based Theory Student Activity Sheets have a significant positive effect on fourth-grade students' mathematics learning outcomes in picture and number pattern materials. The findings contribute to elementary mathematics education by providing an effective instructional tool that supports meaningful and conceptually grounded learning.

Keywords: *Bruner-Based Theory, Student Activity Sheet, Learning Outcomes, Elementary School.*

INTRODUCTION

Mathematics is a fundamental subject in elementary education because it develops students' logical, analytical, and problem-solving skills that are essential for

higher-level learning (Miagusttin et al., 2025). One of the important topics taught in grade IV elementary school is picture and number patterns. This topic serves as a foundation for algebraic thinking because students are required to identify relationships, recognize regularities, and predict subsequent patterns. Mastery of pattern concepts helps students develop mathematical reasoning and critical thinking skills (Febryanti & Ahmad, 2024).

Despite its importance, picture and number pattern material remains challenging for many elementary school students (Indriani et al., 2025). Students are often able to identify simple patterns but experience difficulties when required to explain the underlying rules or apply them to new situations (Devi & Amir, 2021). Previous studies have shown that students' difficulties are closely related to the abstract nature of mathematical concepts and the dominance of teacher-centred instructional approaches (Sinaga et al., 2024). In many classrooms, learning activities are still dominated by lectures and procedural exercises, limiting opportunities for students to explore concepts actively and construct their own understanding (Utami et al., 2025). Consequently, students tend to memorize procedures rather than understand the logic behind mathematical patterns, resulting in low learning outcomes.

Recent studies have emphasized the importance of active and student-centred learning materials in improving mathematics achievement. Research by (Fitriah et al., 2024) reported that well-designed student activity sheets enhanced students' critical thinking skills and engagement in mathematics learning. Similarly, (Syifa et al., 2025) found that the integration of visual learning resources significantly improved students' conceptual understanding of mathematical topics. Furthermore, (Handayaningsih et al., 2025) demonstrated that activity-based learning materials positively influenced students' confidence and problem-solving abilities. These findings indicate that learning resources should facilitate active exploration rather than merely provide routine exercises.

One instructional approach that aligns with this need is Jerome Bruner's learning theory. Bruner proposes that meaningful learning occurs through three sequential modes of representation: enactive, iconic, and symbolic (Mubin, 2022). In the enactive stage, students learn through direct manipulation of objects and concrete experiences. In the iconic stage, learning is supported by visual representations such as pictures and diagrams. Finally, in the symbolic stage, students use mathematical symbols and abstract reasoning. This progression enables learners to gradually construct conceptual understanding from concrete experiences to abstract thinking,

making Bruner's theory particularly relevant for elementary mathematics learning (Bruner, 1966).

Several previous studies have investigated the application of Bruner's theory in mathematics education. (Maharani & Rokan., 2023) reported that constructivist learning approaches based on Bruner's theory improved students' conceptual understanding in elementary mathematics. (Ashirah et al., 2025) found that Bruner's stages of representation enhanced students' engagement and comprehension in fraction learning. Likewise, (Hulu et al., 2025) showed that learning activities designed according to Bruner's principles supported inductive and deductive reasoning processes. Although these studies demonstrate the effectiveness of Bruner's theory, most focus on general mathematics learning or different mathematical topics. Few studies specifically examine the implementation of Bruner-Based Theory Student Activity Sheets in picture and number pattern learning among fourth-grade elementary school students.

Therefore, a research gap exists in the literature. Previous studies have largely investigated Bruner's theory as a learning approach or teaching strategy, while limited research has integrated the three modes of representation into a structured student activity sheet specifically designed for picture and number pattern materials. Moreover, empirical evidence regarding the effectiveness of such activity sheets on elementary students' learning outcomes remains limited, particularly in the context of Indonesian elementary schools (Artini et al., 2023).

To address this gap, this study aims to develop and implement Bruner Based-Theory Student Activity Sheets that systematically guide students through enactive, iconic, and symbolic learning activities in picture and number pattern materials. The novelty of this research lies in the integration of Bruner's three modes of representation into a single instructional worksheet specifically designed for Grade IV in picture and number pattern learning. Unlike previous studies that applied Bruner's theory in broader mathematics contexts, this study focuses on a specific mathematical topic and evaluates its effectiveness using a quasi-experimental design. Therefore, this research contributes both theoretically and practically by extending the application of Bruner's theory in elementary mathematics education and providing an innovative learning resource that can improve students' learning outcomes. Based on the identified problem and research gap, this study aims to examine the effect of Bruner-Based Theory Student Activity Sheets on the learning outcomes of fourth-grade elementary school students in picture and number pattern learning.

METHODS

This study employed a quasi-experimental design using a non-equivalent control group design to examine the effect of Bruner-Based Theory Student Activity Sheets on fourth-grade students' learning outcomes in picture and number pattern materials. Two intact classes were assigned as the experimental group and the control group without randomization. The experimental group received instruction using Bruner-Based Theory Student Activity Sheets, whereas the control group received conventional instruction.

Both groups completed a pre-test before the intervention and a post-test after the intervention. The pre-test was administered to determine the initial equivalence of the groups, while the post-test was used to measure differences in learning outcomes following the intervention. This design enabled a comparison of learning outcomes between students who learned using Bruner-Based Theory Student Activity Sheets and those who received conventional instruction under regular classroom conditions.

The research sample in this study consisted of elementary school students who were purposively selected to represent the population of fourth-grade students. A total of 88 fourth grade students were first involved in the trial phase to test the validity and reliability of the learning outcome instruments. In the main experimental phase, two intact classes of fourth graders were involved and divided into an experimental group (EG) and a control group (CG). The experimental group was taught using Bruner Based-Theory Student Activity Sheets while the control group received instruction through conventional methods. Both groups took a pre-test and post-test so that the researchers could measure the differences in learning outcomes before and after the intervention (Widodo, 2021). This sampling design follows a non-equivalent control group model, which is commonly used when randomization is not feasible in an educational context. The sampling process ensures that both groups have similar academic characteristics, thereby enhancing the comparability of the research results.

The learning outcomes test consisted of 20 items and was piloted with 88 elementary school students prior to the main study. Instrument reliability is assessed using Cronbach's Alpha, while construct validity is examined through Exploratory Factor Analysis (EFA) using JAMOVI version 2.7.12. A Cronbach's Alpha value of 0.70 or higher is considered acceptable for reliability (Nunnally, 1978). The analysis showed that the instrument had excellent reliability with a Cronbach's Alpha value of 0.981. Construct validity was supported by Bartlett's Test of Sphericity ($\chi^2 = 3030$, df = 190, $p < .001$), indicating that the correlation matrix was suitable for factor analysis. Furthermore, the

scree plot revealed a single dominant factor, suggesting that the instrument was unidimensional and consistently measured the intended construct of learning outcomes. A summary of the validity and reliability results is presented in Table 1.

Table 1. Instrument Validity and Reliability

Measure	Result	Interpretation
Cronbach's Alpha	0.981	Excellent reliability
Bartletts's Test of Sphericity	$\chi^2 = 3030$, df = 190, $p < .001$	Suitable for factor analysis
Scree Plot	One dominant factor	Evidence of construct validity

For operational product testing, this study used a quasi-experimental design. Before data analysis was conducted, two prerequisite tests were carried out. First, a normality test aims at determining whether the data from each variable are normally distributed. The normality test is applied to learning outcome data (pre-test and post-test) collected from two classes, namely the control class (CC) and the experimental class (EC). The data are then statistically analysed using Jamovi version 2.7.12 with the Shapiro-Wilk Multivariate Normality Test to evaluate the normality assumption. If $p > 0.05$, the data are considered normally distributed; if $p < 0.05$, the data are considered not normally distributed (Leedy & Ormrod, 2020). The normality test is conducted on pre-test and post-test scores. The criteria for hypothesis testing are as follows, H0: The data are normally distributed; H1: The data are not normally distributed.

Second, homogeneity testing is conducted to determine whether the samples used in the study come from populations with the same variance. This process is carried out using Jamovi version 2.3.28. Homogeneity is determined based on the significance value (sig.); if sig. > 0.05, the data is considered homogeneous, whereas if sig. < 0.05, the data is considered not homogeneous. Homogeneity testing is applied to both pre-test and post-test data. The criteria for hypothesis testing are as follows, H0: the group is homogeneous; H1: the group is not homogeneous.

A field trial uses a non-equivalent control group design, which is similar to a pretest-posttest control group design. This design allows for comparison between the control class and the experimental class, enabling the researcher to assess the effect of the intervention while also accounting for initial differences between the two groups.

Table 2. Quasi-Experimental Design with Non-equivalent Control Group Design

Experiment (KE)	*pre-test measure*	*treatment*	*post-test measure*
	O_1	X_1	O_2
Control (KK)	*pre-test measure*	*treatment*	*post-test measure*
	O_3	-	O_4

(Sugiyono, 2021)

To determine the difference in average scores between the control class and the experimental class, an independent sample t-test is used. Before hypothesis testing is conducted, all prerequisite tests have been carried out to ensure the suitability of the data (assumption tests). The t-test was used to examine the effect of the independent variable, namely learning using Bruner-Based Theory Student Activity Sheets in the material of pattern images and number patterns, on the dependent variable, namely the learning outcomes. The analysis was conducted using JAMOVI version 2.7.12, with a significance level of 5% ($\alpha = 0.05$).

The research hypothesis is formulated as follows, H0: There is no significant difference in the learning outcomes of students who receive instruction using Bruner-Based Theory Student Activity Sheets and those who do not use it ($\mu1 = \mu2$); Ha: There is a significant difference in the learning outcomes between students who receive instruction using Bruner-Based Theory Student Activity Sheets and those who do not use it ($\mu1 \neq \mu2$). This design allows researchers to investigate the effects of treatment in both control and experimental groups, providing a clear comparison between the experimental and control groups, so that the impact of Bruner-based picture and number pattern worksheets on student outcomes can be reliably assessed.

RESULTS AND DISCUSSION

Results

The learning outcomes instrument was piloted with 88 elementary school students prior to the main study.

Table 3. Scale Reliability Statistics

	Mean	**Cronbach's α**
scale	0.853	0.981

Source: Jamovi, 2025

Reliability analysis using JAMOVI produced a Cronbach's Alpha value of 0.981, indicating excellent internal consistency. Construct validity was examined through Exploratory Factor Analysis (EFA).

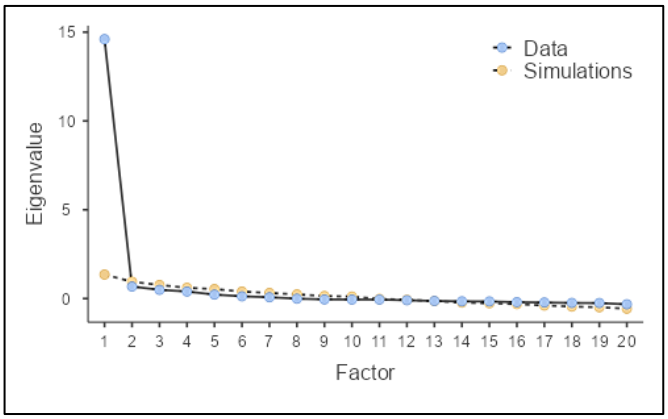

Figure 1. Scree Plot Exploratory Factor Analysis (EFA)

Table 4. Bartlett's Test of Sphericity

χ^2	df	p
3030	190	<.001

Source: Jamovi, 2025

Bartlett's Test of Sphericity showed significant results (χ^2 = 3030, df = 190, p < .001), indicating that the data were suitable for factor analysis. Furthermore, the scree plot revealed one dominant factor, suggesting that the instrument measured a single construct. Before hypothesis testing, the assumptions of normality and homogeneity were examined. Normality test is in the Table 4.

Table 5. Normality Test (Shapiro-Wilk)

	W	p
Pre Test	0.974	0.404
Post Test	0.961	0.142

Source: Jamovi, 2025

The Shapiro–Wilk test showed that the pretest and posttest data were normally distributed, with p-values of 0.404 and 0.142, respectively.

Table 6. Homogeneity of Variances Test (Levene's)

	F	df	df2	p
Pre Test	0.196	1	42	0.660
Post Test	0.102	1	42	0.751

Source: Jamovi, 2025

The homogeneity test using Levene's statistic also indicated homogeneous variances for

both the pretest (p = 0.660) and posttest (p = 0.751). These findings confirmed that the data met the assumptions required for an independent samples t-test.

Table 7. Independent Samples T-Test

		Statistic	df	p
Pre Test	**Student's t**	-1.30	42.0	0.201
Post Test	**Student's t**	-5.82	42.0	<.001

Source : Jamovi, 2025

The study involved 88 fourth-grade students consisting of 46 students in the experimental group and 42 students in the control group. The experimental group received instruction using Bruner-Based Theory Student Activity Sheets, whereas the control group received conventional instruction. The independent samples t-test showed no significant difference between the two groups on the pre-test (t = -1.30, p = 0.201), indicating comparable initial abilities. However, a significant difference was found on the post-test (t = -5.82, p < .001). Students in the experimental group achieved higher learning outcomes than those in the control group.

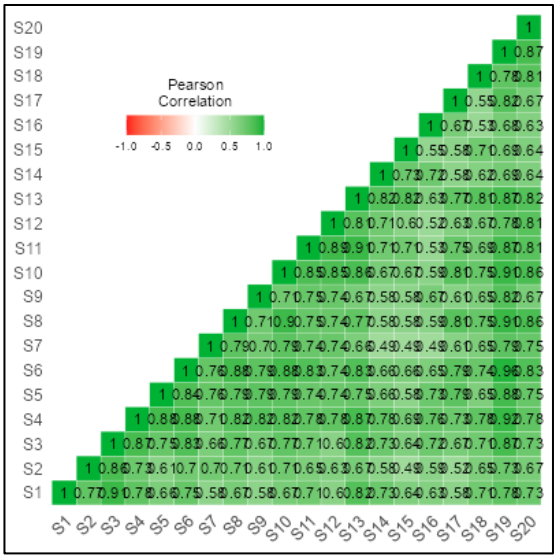

Figure 2. Correlation Heatmap of Learning Outcome Instrument Reliability (Jamovi, 2025)

The findings of this study demonstrated that Bruner-Based Theory Student Activity Sheets significantly improved fourth-grade students' learning outcomes in picture and number pattern materials. The significant difference between experimental and control groups indicates that learning activities designed according to Bruner's theory can facilitate students' understanding on mathematical concepts more effectively

than conventional instruction (Andita et al., 2023). These findings suggest that the effectiveness of the activity sheets lies not only in the use of worksheets as learning materials but also in the structured learning process that guides students from concrete experiences to abstract reasoning.

The positive effect observed in this study can be explained through Bruner's theory of representation, which emphasizes the sequential progression of enactive, iconic, and symbolic learning. Picture and number pattern materials are often challenging because students are required to identify relationships and generalize rules from abstract numerical representations (Karimah, 2025). Through Bruner-Based Theory Student Activity Sheets, students first explored patterns using concrete activities, then interpreted them through visual representations, and finally expressed them using mathematical symbols. This gradual transition reduces cognitive load and enables students to construct conceptual understanding more effectively (Azaria et al., 2025). Consistent with constructivist learning theory, knowledge is acquired more meaningfully when students actively build understanding through exploration and discovery rather than merely receiving information from teachers (Mandar & Sihono, 2025).

The findings are consistent with several recent studies on the application of Bruner's theory in mathematics learning. (Maharani & Rokan, 2023) reported that Bruner-based learning improved elementary students' conceptual understanding of mathematics. Similarly, (Ashirah et al., 2025) found that learning activities structured according to enactive, iconic, and symbolic stages increased students' engagement and comprehension of mathematical concepts. (Hulu et al., 2025) demonstrated that Bruner oriented instructional activities strengthened students' inductive and deductive reasoning skills. In addition, (Fitriah et al., 2024) reported that activity sheets based learning enhanced students' critical thinking abilities, while (Syifa et al., 2025) found that visual learning resources significantly improved conceptual understanding in mathematics. (Handayaningsih et al., 2025) further showed that activity-based instructional materials increased students' confidence and problem-solving abilities. The present study supports these findings by confirming that structured learning activities grounded in Bruner's theory positively affect students' learning outcome.

However, the findings of this study also extend previous research in several ways. Earlier studies focused on the application of Bruner's theory as a general instructional approach or examined its effectiveness across broad mathematics topics. In contrast, the present study specifically integrates Bruner's three modes of

representation into a single Student Activity Sheet designed for picture and number pattern materials. Therefore, the contribution of this study lies not only in learning outcomes of Bruner's theory but also in demonstrating how the theory can be operationalized through a structured instructional resource. This distinction represents an important contribution to elementary mathematics education, particularly in addressing students' difficulties with abstract concepts.

From a theoretical perspective, the findings strengthen constructivist views of learning by providing empirical evidence that conceptual understanding develops more effectively when student progress through concrete, visual, and symbolic representations (Safira et al., 2025). The study also extends the application of Bruner's theory to pattern learning, a topic that has received relatively limited attention in previous research. From a practical perspective, the findings suggest that teachers can utilize Bruner-Based Theory Student Activity Sheets as an alternative instructional resource for teaching abstract mathematical concepts. The structured learning sequence embedded within the activity sheets may help increase student participation, engagement, and conceptual understanding while reducing dependence on teacher centred instruction (Laulaleng et al., 2025).

Despite these contributions, several limitations should be acknowledged. First, the study was conducted in a single elementary school, which may limit the generalizability of the findings to different educational contexts. Second, the intervention focused exclusively on picture and number pattern materials in Grade IV mathematics. Third, the study primarily measured cognitive learning outcomes and did not examine other variables such as learning motivation, critical thinking skills, or long-term knowledge retention. Future studies are therefore recommended to investigate the effectiveness of Bruner-Based Theory Student Activity Sheets in other mathematical topics, including fractions, geometry, and algebraic thinking, as well as involving larger and more diverse samples. Further research may also explore the impact of these activity sheets on students' motivation, problem-solving abilities, and higher-order thinking skills.

CONCLUSION

The study demonstrates that mathematics learning outcomes is enhanced when abstract concepts are introduced through a structured progression from concrete manipulation to symbolic reasoning. The findings contribute to the development of constructivist learning theory by demonstrating how Bruner's enactive, iconic, and symbolic representations can be systematically integrated into a structured learning

resource for elementary mathematics instruction. The novelty of this study lies in the implementation of Bruner's three modes of representation within a single Student Activity Sheet specifically designed for picture and number pattern learning, thereby providing an instructional model that bridges the gap between theoretical principles and classroom practice. Practically, the findings offer an alternative learning resource that can assist teachers in creating more meaningful, student centred, and conceptually oriented mathematics learning experiences. However, since this study was conducted within a limited educational setting and focused on a single mathematics topic, future research is recommended to examine the application of Bruner-Based Theory Student Activity Sheets across different mathematical topics, educational levels, including critical thinking, problem-solving skills, and learning motivation, in order to strengthen the generalizability and broader educational impact of the findings.

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