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EFFECTIVENESS OF COUNTING BOX MEDIA ON STUDENT ENGAGEMENT AND MATHEMATICS LEARNING OUTCOMES IN GRADE I ELEMENTARY SCHOOL

Siti Hotimah[1], Wulan Octi Pratiwi[2], Eka Avrianti[3], Yogi Krisma Yuliana[4], Latifah Arrodiyah[5], Komalasari[6]

[1,2,3,4,5,6]Teacher Education Madrasah Ibtidaiyah, STIT Pringsewu

khotimaah2004@gmail.com1 , wulanoctipratiwi@gmail.com[2], ekaavrianti76@gmail.com3 , yogiyogikharismayuliana@gmail.com4 , lathifaharrodiyah3@gmail.com5 , komalasari202424@gmail.com

ABSTRACT

This study aims to examine the association between counting box media use, student engagement, and mathematics learning outcomes in Grade I elementary school. A quantitative approach was employed using a pre-experimental one group pretest-posttest design with 25 Grade I students. Data were collected through pretest and posttest instruments, observation sheets, and student engagement questionnaires. Because the sample was small (n = 25), the Shapiro-Wilk test was used to examine the normality of the difference scores and yielded W = 0.957 with a significance value of p = 0.358 (p > 0.05), indicating that the data met the normality assumption. A paired samples t-test showed a statistically significant mean difference between pretest (M = 58.4, SD = 15.6) and posttest (M = 88.2, SD = 8.3) scores, t(24) = 11.20, p < 0.001, 95% CI [24.31, 35.29], with a very large effect size (Cohen's dz = 2.24). The mean N-Gain score was 0.72, classified as High. Student engagement reached an average of 88.6% (Very High), comprising behavioral (92%), emotional (86%), and cognitive (88%) engagement. Given the absence of a control group, these findings should be interpreted with caution; they suggest that counting box media has the potential to support the transformation of abstract arithmetic concepts into concrete manipulative experiences consistent with the concrete-operational cognitive stage of Grade I students, and warrant further confirmation through quasi-experimental or randomized designs.

Keywords: counting box, learning outcomes, mathematics elementary school, student engagement, concrete media

A. INTRODUCTION

Mathematics is often seen as a heavy and uninteresting subject by most elementary school students, so they tend to be less enthusiastic and easily lose attention in the classroom. This negative view has a direct impact on students' low engagement, which in turn suppresses their overall academic achievement. The problem is made more complicated because the teaching approach applied in many schools still relies on monotonous old methods, without maximizing the potential of more varied and interesting learning media. Student involvement itself can be observed from three sides: behavioral (e.g. actively asking questions and participating), emotional (enthusiasm and liking for lessons), and cognitive (the ability to concentrate and process material). (Mulyaningsih, T., & Saraswati, 2021)

Students who were truly engaged in the learning process were shown to have a greater chance of understanding the material and achieving satisfactory results. Affirming that high engagement significantly makes it easier for students to absorb lessons while encouraging improvement in their learning achievement. Similar findings were put forward by those who found a close link between student engagement and their achievement in elementary

mathematics, with a relatively strong correlation coefficient value of r = 0.67. Wulandari et al. (2023) Husain, R., & Haris (2023)

In the context of learning, media acts as an intermediary that helps convey messages from teachers to students so that learning goals can be achieved in a more effective way. The presence of the right media allows teachers to present material in a more real and easy to understand way, so that concepts that originally felt abstract become more affordable to students' minds. More than that, attractively packaged media has proven to be able to arouse enthusiasm and encourage students to be more actively involved in learning activities. Remind that the key to the successful use of media lies in its suitability with the student's developmental stage, because the right choice can have a significant impact on the motivation to learn mathematics. (Amalia, 2021) Febriani, C., & Prasetyo (2022)

Among the wide selection of media available for mathematics learning, the counting box comes as one of the promising alternatives. This media is in the form of a counting box designed so that students can directly hold, move, and manipulate real objects while learning the concepts of numbers and basic counting operations. For grade I elementary school students who are still in the concrete operational stage, this kind of approach is needed because their way of thinking is still highly dependent on real physical experience. This is in line with the theoretical framework of cognitive development which states that children aged 7-11 years learn most effectively through direct interaction with objects around them, so concrete media becomes the right foundation in building an initial mathematical understanding. (Augustine, 2022) Piaget (1952)

The success of the learning process is ultimately reflected in the learning outcomes, namely the extent to which students are able to master the material that has been taught, which is usually measured through test instruments. Unfortunately, the picture of the mathematical competence of Indonesian students in general is still concerning. PISA 2022 data recorded that the mathematics score of Indonesian students only reached 366 points, far below the average of OECD countries which is at 472 points. This gap is a strong signal that a breakthrough in learning based on concrete media is needed that is able to bridge the gap between conceptual understanding and reality in the classroom. (Arikunto, 2021) (Zubaidah, N., & Suyitno, 2020)

In order to measure how much change occurs after a learning intervention, this study uses N-Gain analysis with paired t-tests as the main measuring tool. explains that the combination of inferential testing and N-Gain analysis is a reliable approach to assess the effect of a treatment on improving student learning outcomes. The initial conditions found in the field show quite serious problems: the average student active participation rate is below 60%, the use of media is still very limited, and the understanding of basic calculation operations is weak, as reflected in the average class score of only 58.4. Sugiyono (2022)

Departing from the above explanation, this study is designed to answer three main questions: (1) how the level of student involvement during learning takes place with media counting boxes; (2) how much influence does the use of media have on the mathematics learning outcomes of grade I elementary school students; and (3) what is the picture of the improvement in learning outcomes measured through N-Gain analysis. Thus, this study as a whole aims to describe student involvement, analyze the influence of media counting boxes on mathematics learning achievement, and calculate the amount of improvement resulting from the application of these media.

The theoretical basis of this research is rooted in Jean Piaget's idea of how children's intelligence develops gradually through four phases: sensorimotor, preoperational, concrete operational, and formal operational. Children in grade I of elementary school are generally still in the concrete operational phase, which is the age range of 7 to 11 years, where their logical reasoning skills are growing but are still highly dependent on objects that can be seen and touched directly. Therefore, concrete teaching aids act as an indispensable bridge between abstract concepts and students' real understanding. reinforces this by emphasizing that learning in the early elementary school should start with direct experience, then move gradually towards image representation, and finally to the abstract level, a principle known as Concrete-Pictorial-Abstract (CPA). This idea is in line with the view that new knowledge will only be truly meaningful when it is connected to what is already in the minds of students, and this is where concrete media plays an irreplaceable role. (Piaget, 1952) (Irwanto & Saputro, 2021) Susanto (2021) Grace (2021) .

Various studies that have been conducted previously provide consistent evidence of the advantages of concrete media in building mathematical understanding at the elementary level. It is reported that early childhood children who learn to count using box counting media experience a significant increase in ability, with an average increase of 34.2%. In the context of elementary school, Angelia et al. (2023) found that the use of similar media was associated with an increase in mathematics learning outcomes with an average N-Gain score of 0.65. added that manipulative media is helpful because it makes the process of addition and subtraction something that can be seen and felt directly by students, not just numbers on the board. Sari et al, (2022) Fadillah & Wahyuni (2023) .

The success of learning is also highly determined by how deeply students are involved in the process. Student engagement is a multidimensional construct, covering three sides at once: behavioral engagement, emotional engagement, and cognitive engagement, each of which represents physical participation, affective response, and how much students devote their thoughts to learning. Through a meta-analysis study, it was found that students with high involvement tend to excel in mathematics, with relatively strong relationship strength ($r = 0.67$). It also shows that the depth of students' cognitive involvement is directly proportional to their ability to solve problem-solving problems. Based on these findings, encouraging student involvement through interesting and active media is one of the strategic steps that cannot be ignored in efforts to improve the quality of mathematics learning in elementary schools. (Solichah et al, 2023) Husain & Haris (2023) Nurhaliza & Wahyudi (2024) .

B. RESEARCH METHODS

This study took a quantitative path with a pre-experimental design, precisely using a one-group pretest-posttest design pattern. The selection of this design was based on the need to see the picture before and after treatment in the same group, in order to find out the change in learning outcomes after the application of media counting box. The location of the study was SDN 1 Pringsewu, involving 25 grade I students who were selected through purposive sampling. The determination of the sample used three considerations: students were recorded as active in class I, had never received learning with media counting boxes before, and were willing to participate in all stages of research from start to finish. (Khairunnisa et al, 2025) .

Data was collected through four paths at once: (1) a written test in the form of a pretest and a posttest containing 20 questions about basic calculation operations, (2) an observation sheet designed to record student engagement from three different dimensions, (3) a questionnaire consisting of 15 statements with a choice of responses on a Likert scale of 1-4, and (4) visual documentation in the form of photos and video recordings during learning activities. It is important to recall that the combination of various data sources like this—commonly called triangulation—is essential to produce a comprehensive and reliable picture of the effectiveness of concrete learning media. Pasambo & Radia (2022) .

The test instrument quality test was carried out in two ways. First, the validity of the question items was checked using Pearson's Product Moment correlation, where an item was declared valid if the r value obtained exceeded the table r of 0.396 (applicable to n=25 with a significance level of 0.05). Of the 25 questions tested, as many as 20 items met the requirements and were declared suitable for use. Second, the consistency level of the instrument was tested using the Alpha Cronbach formula, resulting in a reliability coefficient of 0.87 which was included in the very high category. The student involvement observation sheet had been substantially verified by two experts in the field of basic education before being used in the field. (Arikunto, 2021) .

The implementation of the research is divided into three successive stages. In the first stage or preparation, the researcher compiles learning tools, creates media counting boxes, and validates all instruments. The second stage or implementation begins with giving a pretest to all students, followed by four learning sessions using media counting boxes (each lasting 70 minutes), accompanied by observation of student involvement in each meeting, and ends with a posttest. The third stage or analysis includes data processing through normality tests, inferential difference tests, and N-Gain calculations to measure the amount of improvement that occurs.

Data processing was carried out in three consecutive steps. The first step was the normality test with Shapiro-Wilk. The Shapiro-Wilk selection—instead of the Kolmogorov-Smirnov—was based on the consideration that the Shapiro-Wilk had a higher statistical power on small samples ($n < 50$), so it was more appropriate to use for data with $n = 25$. The normality test was imposed on the difference score (d = posttest − pretest), since the relevant normality assumption for paired t-tests was on the difference distribution, not on individual measurements. The second step was an inferential difference test using a paired sample t-test to test whether the average posttest score differed significantly from the average pretest score. The effect size was reported using Cohen's dz, with interpretation criteria: small (0.2), medium (0.5), large (0.8), and very large (≥ 1.2). The third step is the calculation of N-Gain to measure the magnitude of the improvement in learning outcomes using the formula: (Razali & Wah, 2011; Mishra et al, 2019) (Field, 2018) (Cohen, 1988; Lakens, 2013) .

N-Gain = (Posttest Score − Pretest Score) / (Maximum Score − Pretest Score)

The interpretation of the N-Gain score refers to the criteria of Hake (1999): high ($g > 0.70$), medium ($0.30 \leq g \leq 0.70$), and low ($g < 0.30$). The student engagement data was analyzed descriptively as a percentage with the formula: P = (Acquisition Score / Maximum Score)×100%. All statistical analysis was carried out with the help of IBM SPSS Statistics 26.

C. RESULTS AND DISCUSSION

Normality Test and Data Description

As a first step before the inferential testing was performed, the normality of the data distribution of 25 students was first checked using the Shapiro-Wilk test on the difference score (d = posttest − pretest). The test results showed a value of W = 0.957 with a significance of p = 0.358, exceeding the threshold of 0.05 (p > 0.05), so that the difference score was declared to be normally distributed and the paramteric assumptions for the paired t-test were met. A descriptive summary of the learning outcome data is presented in Table 1. (Razali & Wah, 2011).

Table 1. Description of Learning Outcome Test Scores (n=25)

Test Stage	Average Score	Minimum Score	Maximum Value	Std. Deviation
Pretest	58,4	40	75	15,6
Posttest	88,2	70	100	8,3

Paired Samples t-Test

To test whether there was a statistically significant mean difference between the pretest and posttest scores, a paired sample t-test was performed. The test results are presented in Table 2. t(24) = 11.20 with p < 0.001 was obtained, which means that the null hypothesis (no difference between pretest and posttest) was rejected. The mean difference of 29.80 points with a 95% confidence interval ranged from 24.31 to 35.29 points, indicating a consistent and stable increase at the estimated population level. The size of Cohen's dz effect of 2.24 was very large, which corroborated the finding that the difference was not only statistically significant but also substantial practically. (Cohen, 1988)

Table 2. Paired t-test results Pretest-Posttest scores

Measurement	M (SD)	Red Diff. (95% CI)	t (df=24)	Cohen's dz
Pretest	58,4 (15,6)	29,80 [24,31; 35,29]	11,20	2,24
Posttest	88,2 (8,3)			

Increase Quantity Analysis (N-Gain)

As a complement to the inferential test, the amount of increase was also calculated using normalized N-Gain. From the calculation results, an average N-Gain of 0.72 was obtained. Based on the criteria of Hake (1999), this figure is included in the High category because it exceeds the threshold of 0.70. The details of the N-Gain results for each group of students are presented in Table 3.

Table 3. Details of N-Gain Analysis Per Student Group

Groups	Pretest	Posttest	N-Gain	Categories
Group A (n=5)	52,0	84,0	0,67	Medium
Group B (n=5)	56,0	86,0	0,68	Medium
Group C (n=5)	60,0	90,0	0,75	Height
Group D (n=5)	62,0	90,0	0,74	Height
Group E (n=5)	62,0	91,0	0,76	Height
Overall Average	**58,4**	**88,2**	**0,72**	**Height**

The data in Table 3 show that despite the variation in N-Gain between groups (0.67 to 0.76), all groups experienced consistent improvements. This pattern indicates that the improvement in learning outcomes is not limited to a specific subgroup, but occurs across the entire initial ability level of students in the classroom. (Pratiwi & Rinaldi, 2023).

Student Engagement Results

Student engagement data was obtained from two complementary sources, namely questionnaires and observation sheets, covering three dimensions as seen in Table 4.

Table 4. Percentage of Student Engagement in Learning

Dimension of Engagement	Key Indicators	Score (%)	Categories
Behavior	Motor activity, obedience, manipulative participation	92%	Very High
Emotional	Enthusiasm, comfort, confidence, motivation	86%	Height
Cognitive	Concentration, understanding of the flow of computational operations	88%	Height
Total Average		**88.6%**	**Very High**

Based on Table 4, behavioral engagement reached the highest percentage (92%), followed by cognitive (88%) and emotional (86%) engagement. This pattern indicates that media counting boxes are most strongly associated with the behavioral dimensions of students, namely physical and motor engagement. The trend of emotional engagement increases consistently from meeting to meeting (meeting 1: 78%, meeting 2: 84%, meeting 3: 88%, meeting 4: 93%).

Discussion

The achievement of a N-Gain of 0.72 which is classified as High, supported by significant paired t-test results ($t(24) = 11.20$; $p < 0.001$) with a very large effect size ($dz = 2.24$), indicates a substantial improvement in the learning outcome score after learning based on media counting boxes. This pattern is in line with the conceptual framework outlined and which places concrete media as a bridge between abstract number concepts and physical experiences that students can observe. With this media, counting activities no longer take place solely on a symbolic level, but in the form of physical actions that have the potential to strengthen students' mental representations of the concept of quantity. It should be emphasized that the causal relationship between the use of media counting boxes and the improvement of learning outcomes cannot be fully affirmed in this pre-experimental design, given the absence of a comparison group. Piaget (1952) Augustine (2022) (Lestari & Fitri, 2023).

The highest score on the behavioral dimension (92%) reflected that the media counting box was associated with high physical involvement of students during learning. This is in line with the opinion that attractively packaged media tends to arouse students' interest

and participation. A similar pattern was seen in the emotional dimension (86%), which can be interpreted as an indication of increased student comfort and confidence, as also reported in the context of manipulative teaching aids in elementary schools. However, the association between the dimension of engagement and learning outcomes in this study was descriptive-correlational and did not justify causal claims. Amalia (2021) Maulana et al, (2023).

When the test result data is juxtaposed with the questionnaire data, there is an alignment between the quality of the process and the quality of the results. An average of 88.6% engagement indicates that the media counting box is able to attract and maintain students' focus throughout learning. Explains that learning that provides space for students to engage directly with the material (hands-on learning) is generally associated with better learning outcomes than conventional approaches. Theoretically, high engagement can facilitate deeper information processing, so that the material learned has the potential to last longer in students' memories. However, this mechanism needs to be verified through research with a design that allows control over extra variables. (Wuland et al, 2023) Yuliani & Saragih (2022) (Indriani, 2022).

When compared to the findings of similar studies, the results of this study show a consistent range of achievements. The N-Gain of 0.72 obtained was in the reported range of 0.65 to 0.75, and slightly higher than the reported 0.65. The consistency of this pattern adds weight to the evidence that manipulative concrete media can be a promising pedagogical choice for mathematics learning in early elementary school, although the strength of this claim is still limited by the diversity of design and context between studies. (Angelia et al., 2023) Fadillah & Wahyuni (2023) (Wahyudi, 2022; Syarifuddin, 2021)

This study has a number of limitations that need to be considered in interpreting the findings. First, the one-group pretest-posttest design without a control group makes this study vulnerable to internal validity threats such as maturation effects, testing, history, and regression to the middle value, so causal claims cannot be confirmed. Second, the relatively small sample size (n = 25) and purposive sampling techniques limit the generalization of findings to the broader population of grade I elementary school students. Third, the intervention lasted in four sessions, so the long-term effects and knowledge retention could not be evaluated. Fourth, emotional engagement data partly sourced from the Likert questionnaire of grade I students have the potential to contain social-desirable biases. Therefore, the findings of this study should be viewed as an initial indication that justifies further study, rather than as definitive evidence of the effectiveness of media counting boxes). (Shadish) et al , 2002).

D. CONCLUSION

Based on data analysis from 25 grade I elementary school students, three main conclusions can be formulated. First, the results of the paired t-test showed a statistically significant mean difference between the pretest score (M = 58.4) and posttest (M = 88.2), $t(24) = 11.20$; $p < 0.001$, with a very large effect size (Cohen's dz = 2.24) and an average N-Gain of 0.72 (High category), indicating that media counting box based learning was associated with a substantial improvement in mathematics learning outcome scores. Second, student engagement during learning was recorded at an average of 88.6% (Very High), covering the behavioral dimensions of 92%, cognitive 88%, and emotional 86%, which shows the potential of this medium in facilitating multidimensional participation. Third, this pattern of results is consistent with the framework of Piaget's theory which places concrete media as a bridge that has the potential to support the transformation of abstract concepts of computational operations into manipulative experiences that are appropriate to the stage of concrete operational cognitive development of grade I elementary school students.

Given the limitations of pre-experimental designs without control groups and small sample sizes, these findings should be interpreted as preliminary indications and not as definitive evidence of effectiveness. Strong cause-and-effect claims require confirmation through quasi-experimental or randomized controlled (RCT) designs in larger, diverse samples.

Based on these findings and limitations, several recommendations can be made: (1) elementary school teachers can consider the use of media counting boxes as an alternative in learning counting operations, while still paying attention to the suitability of the classroom context; (2) schools need to consider budget allocations for the procurement of varied concrete manipulative media; (3) further research with quasi-experimental designs or RCTs on larger samples is needed to test the effectiveness of this media more robustly; and (4) the development of an adaptive digital counting box version can be explored as an effort to align concrete media with the demands of digital literacy in elementary schools.

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