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Interactive Digital Demonstration through Ruang Murid for Enhancing Mathematics Motivation and Conceptual Understanding in Early Primary School Children

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ABSTRACT

Purpose of the study: This study examined the use of Interactive Digital Demonstration through Ruang Murid in supporting mathematics learning motivation and cognitive outcomes among Grade 2 primary school students.

Methodology: A quantitative quasi-experimental design with a pretest-posttest control group was employed. The participants consisted of 60 Grade 2 students, with 30 students assigned to the experimental group and 30 students to the control group. The experimental group received mathematics instruction through Interactive Digital Demonstration supported by Ruang Murid, while the control group received conventional demonstration-based instruction. Data were collected using a 20-item mathematics motivation questionnaire and a 15-item cognitive achievement test covering remembering, understanding, applying, and analyzing levels.

Main Findings: Descriptive results showed increases in both groups. In the experimental group, the mean motivation score increased from 64.20 at baseline to 79.10 at the final measurement, while the cognitive score increased from 65.83 to 83.33. In the control group, motivation increased from 63.20 to 76.40, and cognitive scores increased from 65.00 to 77.46. The experimental group therefore demonstrated a larger descriptive increase in both motivation and cognitive outcomes. From a child-development perspective, the findings indicate that interactive digital demonstrations may provide developmentally responsive visual and interactive learning experiences when integrated with teacher-guided instruction.

Novelty/Originality of this study: The findings suggest that Ruang Murid can function as a pedagogical support for primary mathematics learning rather than as a replacement for teacher interaction. Further research involving larger and more diverse samples, individual-level randomization, and inferential statistical analysis is needed to establish the robustness and generalizability of these findings.

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1. INTRODUCTION

Cognitive development during the school-age period is a fundamental component of children's overall development and has important implications for their capacity to learn, reason, and solve academic problems [1], [2], [3]. From a child-development and pediatric perspective, the early primary school years represent an important period in which children progressively develop the ability to organize information, recognize relationships, use logical rules, and connect concrete experiences with more structured representations [4]-[6]. These developmental characteristics have direct implications for mathematics education because mathematical concepts increasingly

require children to move from concrete objects and observable situations toward symbols, procedures, and abstract relationships [7]-[9]. Therefore, mathematics learning for early primary school children needs to consider their cognitive characteristics by providing learning experiences that are concrete, visual, interactive, and appropriately scaffolded [10], [11]. Learning environments that correspond to children's developmental needs may provide stronger opportunities for children to construct mathematical meaning while simultaneously developing positive dispositions toward learning.

Mathematics learning in the early grades of primary school remains challenging because children are required to develop foundational mathematical knowledge while still relying substantially on concrete and visual representations [12]-[14]. Difficulties in understanding mathematical concepts may influence not only children's cognitive achievement but also their motivation and willingness to participate in learning activities. Mathematics motivation is particularly important because motivated learners are more likely to pay attention, participate in learning tasks, persist when facing difficulties, and engage with mathematical problems [15]. Recent research on digital learning in primary mathematics indicates that digital resources can contribute to students' motivation, engagement, and academic achievement; however, these benefits do not automatically emerge from the presence of technology itself. Rather, the effectiveness of digital learning depends on how technological resources are integrated with pedagogical strategies, learning activities, and learners' developmental [16]-[18] . Consequently, the challenge is not simply to introduce digital media into mathematics classrooms but to design learning experiences in which digital resources meaningfully support children's cognitive and motivational development.

One pedagogical approach that may address these needs is demonstration-based learning supported by digital resources. Demonstration allows teachers to present mathematical processes, objects, relationships, or procedures in an observable and sequential manner, enabling children to connect what they see with the concepts being explained [19]. When demonstration is combined with digital resources, mathematical representations can be presented through visual, animated, and interactive formats that may be more accessible to young learners [20], [21]. In the Indonesian educational context, Ruang Murid, as part of the Rumah Pendidikan ecosystem, provides digital learning resources that can be accessed by teachers and students across educational levels. The platform includes various learning resources such as videos, educational games, articles, and virtual laboratories. Importantly, mathematics resources have also been developed for early primary grades, including materials related to numbers, addition, and subtraction. This availability provides an opportunity to integrate a nationally developed digital learning platform into classroom instruction rather than using digital technology merely as an additional source of information.

The integration of digital resources with demonstration learning is particularly relevant when learning outcomes are considered from both motivational and cognitive perspectives. Increased motivation and engagement may provide children with greater opportunities to observe demonstrations, follow explanations, perform procedures, practice mathematical tasks, and respond to feedback during learning. These learning experiences can subsequently support the development of students' cognitive achievement. In the present study, cognitive learning outcomes are limited to four cognitive processes: C1 (remembering), C2 (understanding), C3 (applying), and C4 (analyzing), which are aligned with the learning objectives and the developmental characteristics of Grade 2 primary school children. Accordingly, the integration of interactive digital demonstration with Ruang Murid is expected to create a learning environment in which children are not only exposed to digital content but are actively guided to observe, process, practice, and apply mathematical knowledge. This perspective positions digital technology as a pedagogical support for children's learning processes rather than as a substitute for teacher-guided instruction.

Although research on digital technology in primary mathematics education has expanded considerably, several gaps remain. Previous studies have commonly examined the effects of digital media, interactive applications, educational games, videos, or technology-assisted learning on students' motivation or academic achievement. However, these studies frequently treat digital technology as the primary intervention without sufficiently examining how specific digital resources are pedagogically integrated into teacher-led demonstration activities for early primary school children. Research concerning Ruang Murid is also still emerging. Existing studies have examined its use in primary mathematics learning, including research involving higher primary grades and problem-based learning contexts, but evidence concerning its integration with interactive demonstration for younger children remains limited. More importantly, relatively little attention has been given to the simultaneous examination of a motivational outcome—mathematics motivation and a cognitive outcome represented by C1–C4 learning achievement within an early primary school context. This gap is important because the effectiveness of digital learning for children cannot be adequately understood from technology exposure alone; it requires consideration of the interaction between digital representation, teacher scaffolding, learner engagement, and developmental characteristics.

The novelty of the present study therefore lies in the integration of Interactive Digital Demonstration through Ruang Murid as a child-oriented learning experience specifically designed for early primary school mathematics. The novelty is not simply the use of Ruang Murid as a digital platform, but the pedagogical integration of its digital resources into a structured demonstration process in which children observe mathematical

representations, attend to teacher explanations, engage with digital content, practice procedures, and receive feedback. This approach connects concrete and visual demonstration with digital representation while maintaining teacher-guided scaffolding appropriate for young learners. In addition, the study examines two complementary dimensions of learning outcomes: mathematics motivation as an affective dimension and cognitive learning outcomes as a cognitive dimension. By positioning the developmental characteristics of early primary school children as an important consideration in the design of digital mathematics learning, this study extends existing research from a technology-centered perspective toward a more developmentally responsive and pedagogically integrated perspective. The study thus contributes empirical evidence on how a national digital learning platform can be meaningfully embedded within classroom instruction for young mathematics learners.

The urgency of this study is related to the growing integration of digital learning resources into primary education and the need to ensure that such integration remains consistent with children's developmental and educational needs. The availability of Ruang Murid provides teachers with opportunities to access nationally developed digital learning resources, but the educational value of these resources depends on how they are incorporated into meaningful instructional experiences. For early primary school children, this issue is particularly important because learning activities need to simultaneously support cognitive development, motivation, engagement, and foundational academic achievement. Therefore, empirical evidence is needed to determine whether an interactive digital demonstration approach using Ruang Murid can contribute to these learning dimensions. Accordingly, this study aims to examine the effect of Interactive Digital Demonstration through Ruang Murid on mathematics motivation and cognitive learning outcomes among early primary school children. The findings are expected to provide empirical evidence for teachers and researchers regarding the pedagogical integration of digital learning resources in early primary mathematics education and to contribute to the development of child-centered digital learning practices that support both motivational and cognitive aspects of children's learning.

2. RESEARCH METHOD

2.1 Research Design

This study employed a quantitative approach using a quasi-experimental method with a pretest-posttest control group design [22]-[24]. The design was selected because the study was conducted in an existing school setting in which students could not be randomly assigned individually to experimental and control groups. The study examined the effect of Interactive Digital Demonstration through Ruang Murid on two dependent variables, namely mathematics motivation and cognitive learning outcomes among early primary school children [25], [26]. The experimental group received demonstration-based mathematics instruction supported by digital learning resources available through Ruang Murid, including relevant visual materials, animations, interactive activities, and digital learning tasks. The control group received demonstration-based mathematics instruction using conventional learning resources, such as textbooks, teacher explanations, whiteboards, pictures or cards, worksheets, and concrete teaching aids. Both groups received the same mathematics content, learning objectives, instructional duration, and teacher, while the primary difference was the integration of digital resources through Ruang Murid in the experimental group. The research design is presented in Table 1.

Table 1. Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental	O_1: Mathematics motivation and cognitive learning outcomes	X_1: Interactive Digital Demonstration through Ruang Murid	O_2: Mathematics motivation and cognitive learning outcomes
Control	O_3: Mathematics motivation and cognitive learning outcomes	X_2: Demonstration-based conventional learning	O_4: Mathematics motivation and cognitive learning outcomes

The notation in the design is defined as follows: O_1 and O_3 represent the pretest measurements administered to the experimental and control groups, respectively; O_2 and O_4 represent the corresponding posttest measurements; X_1 represents the interactive digital demonstration treatment supported by Ruang Murid; and X_2 represents conventional demonstration-based instruction.

2.2 Participants and Sampling

The population consisted of all Grade 2 students at SD Negeri Jagatamu during the academic year in which the study was conducted. The research sample consisted of two existing Grade 2 classes selected as the experimental and control groups. Because the study was conducted in an intact classroom setting, class assignment was maintained without individual randomization. The experimental group received mathematics instruction using

Interactive Digital Demonstration through Ruang Murid, whereas the control group received demonstration-based instruction using conventional learning resources. The number of students in each group should be reported based on the actual research sample: [n = 30 students in the experimental group] and [n = 30 students in the control group]. To minimize potential confounding variables, both groups were taught the same mathematics material, pursued the same learning objectives, received the same instructional duration, and were taught by the same teacher. The treatment was therefore differentiated primarily by the use of Ruang Murid as the digital learning support in the experimental group.

2.3 Learning Treatment

The intervention focused on mathematics content concerning whole-number operations, including place value, addition, subtraction, basic multiplication and division, and mathematical word problems. The learning activities were organized around demonstration-based instruction. In the experimental group, the teacher first introduced the learning objective and mathematical problem, followed by a demonstration of the problem-solving process using relevant digital resources available through Ruang Murid. Students observed visual or animated representations, interacted with relevant digital activities, practiced the demonstrated procedures, completed learning tasks, and received feedback from the teacher. The teacher remained responsible for guiding interpretation of the digital representations and correcting students' misconceptions or procedural errors [19].

In the control group, the teacher implemented the same demonstration-oriented learning sequence and mathematics content but used conventional learning resources. Demonstrations were presented through the whiteboard, textbooks, pictures or cards, worksheets, and concrete teaching aids. Students observed the demonstration, attempted the procedures, practiced mathematical problems, and received teacher feedback.

The differences between the two treatment conditions are summarized in Table 2.

Table 2. Differences between Experimental and Control Treatments

Component	Experimental Group	Control Group
Learning approach	Demonstration-based learning	Demonstration-based learning
Digital support	Ruang Murid	Not used
Main learning resources	Videos, visual materials, animations, educational games, and relevant Ruang Murid resources	Textbooks, whiteboard, pictures/cards, worksheets, and concrete teaching aids
Mathematics content	The same mathematics content	The same mathematics content
Learning objectives	The same	The same
Instructional duration	The same	The same
Teacher	The same teacher	The same teacher
Core learning activities	Observing demonstrations, practicing procedures, completing tasks, and receiving feedback	Observing demonstrations, practicing procedures, completing tasks, and receiving feedback
Evaluation	Mathematics motivation questionnaire and cognitive learning test	Mathematics motivation questionnaire and cognitive learning test

2.4 Research Procedure

The research procedure consisted of three main stages: pre-intervention, intervention, and post-intervention.

2.4.1 Pre-intervention

Before the treatment, both groups were administered a mathematics motivation questionnaire and a cognitive learning test as pretests. The pretest was conducted to identify the initial condition of the two groups before the intervention. The researcher also prepared the learning materials, digital resources, instruments, and observation sheets required for the implementation of the treatment.

2.4.2 Intervention

The experimental group received mathematics learning through Interactive Digital Demonstration supported by Ruang Murid. The teacher presented mathematical concepts through demonstrations supported by visual and interactive digital resources. Students observed the demonstrations, responded to questions, participated in digital activities, practiced mathematical procedures, and received immediate clarification and feedback.

The control group received the same mathematics content through demonstration-based learning but without the integration of Ruang Murid. The teacher demonstrated mathematical procedures using conventional resources, while students observed, practiced, completed worksheets, and received feedback.

During the intervention, an observation sheet was used to monitor the implementation of the treatment in the experimental classroom. The observation focused on preparation, presentation of digital learning materials, student interactivity, feedback, and completion of digital learning tasks.

2.4.3 Post-intervention

After the intervention was completed, both groups were administered the same mathematics motivation questionnaire and cognitive learning test as posttests. The pretest and posttest data were then compared to determine changes in mathematics motivation and cognitive learning outcomes and to examine the effect of the intervention.

2.5 Research Instruments

Two primary instruments were used to collect the outcome data: (1) a mathematics motivation questionnaire and (2) a cognitive mathematics learning test. In addition, an observation sheet was used to monitor treatment implementation in the experimental group. Before data collection, the instruments were subjected to appropriate validity and reliability procedures. The motivation questionnaire was assessed for content and construct validity and internal consistency, while the cognitive learning test was examined for item validity, reliability, difficulty, and discrimination where applicable.

Mathematics motivation was measured using a 20-item Likert-scale questionnaire. The questionnaire consisted of intrinsic motivation, extrinsic motivation, learning environment, and persistence dimensions. Each item was scored using a Likert scale according to the response options established in the final instrument.

Table 3. Blueprint of the Mathematics Motivation Questionnaire

No.	Dimension	Indicator	Item Numbers	Number of Items
1	Intrinsic Motivation	Desire and willingness to succeed in mathematics	1, 2, 3	3
		Motivation and perceived need to learn	4, 5, 6	3
2	Extrinsic Motivation	Appreciation, reward, or praise in learning	7, 8	2
		Interesting learning activities supported by Ruang Murid	9, 10, 11	3
3	Learning Environment	A conducive learning environment	12, 13, 14	3
4	Persistence	Persistence in completing difficult tasks	15, 16, 17	3
		Perseverance in facing difficulties and not giving up easily	18, 19, 20	3
	Total			20

The questionnaire was administered before and after the intervention. The pretest measured students' initial mathematics motivation, while the posttest measured mathematics motivation following the learning intervention. Cognitive learning outcomes were measured using a 15-item objective test in multiple-choice format. The test focused on whole-number operations appropriate for Grade 2 mathematics. The cognitive domain covered four levels: C1 (remembering), C2 (understanding), C3 (applying), and C4 (analyzing).

Table 4. Blueprint of the Cognitive Mathematics Learning Test

No.	Content	Item Indicator	Cognitive Level	Item Numbers	Number of Items
1	Whole Numbers	Students determine the place value of tens and ones	C1 – Remembering	1, 2	2
2	Addition and Subtraction	Students calculate the result of two-digit addition using regrouping	C2 – Understanding	3, 4	2
		Students calculate subtraction using regrouping	C2 – Understanding	5, 6	2
3	Basic Multiplication and Division	Students convert repeated addition into multiplication	C3 – Applying	7, 8	2

		Students calculate simple division using repeated subtraction	C3 – Applying	9, 10	2
4	Word Problems	Students solve everyday problems involving addition and subtraction	C4 – Analyzing	11, 12, 13	3
		Students analyze word problems involving basic multiplication	C4 – Analyzing	14, 15	2
Total					15

The test was administered as both a pretest and a posttest. The same test blueprint was used to ensure comparability of the cognitive outcomes before and after the intervention. An observation sheet was used to examine the fidelity of the Interactive Digital Demonstration treatment in the experimental group. The observation instrument used a four-point Likert scale, with higher scores indicating stronger implementation of the intended treatment.

Table 5. Blueprint of the Treatment Implementation Observation Sheet

No.	Observation Aspect	Observation Indicator	Scale
1	Preparation	The teacher prepares the required devices and logs into Ruang Murid before learning begins	1–4
2	Material Presentation	Visual or animated materials in Ruang Murid are presented according to the learning topic	1–4
3	Interactivity	Students actively participate in relevant interactive quizzes or digital learning activities	1–4
4	Feedback	The teacher uses explanations or discussion features associated with the digital learning activity to address students' errors	1–4
5	Evaluation	Students complete digital missions, exercises, or learning tasks provided through the learning resources	1–4

The observation results were used primarily to document treatment implementation and determine whether the planned digital demonstration activities were carried out as intended. The observation score was not treated as the primary dependent variable.

2.6 Validity and Reliability

Instrument quality was established before the main data collection. Content validity was examined by experts with relevant expertise in primary mathematics education, educational technology, and educational measurement. The experts evaluated the relevance, clarity, appropriateness, and alignment of the items with the study constructs and learning objectives. For the mathematics motivation questionnaire, construct validity was examined using item-level validity analysis, followed by reliability analysis to determine the internal consistency of the instrument. For the cognitive learning test, item validity, reliability, difficulty level, and discrimination characteristics were examined where appropriate. Items that did not meet the predetermined criteria were revised or removed before the instruments were used in the main study.

2.7 Data Analysis

Data analysis was conducted using descriptive and inferential statistics at a significance level of $\alpha = 0.05$. First, descriptive statistics were calculated for each group, including the mean, standard deviation, minimum, maximum, and pretest-posttest changes for mathematics motivation and cognitive learning outcomes. These statistics were used to describe the initial and final conditions of the experimental and control groups. Second, prerequisite analyses were conducted before inferential testing. The Shapiro–Wilk test was used to examine the normality of the data, while Levene's test was used to assess homogeneity of variance. Because the study involved two related outcome variables, the assumptions required for multivariate analysis were also examined.

Third, inferential analysis was conducted to determine whether the intervention produced statistically significant differences in the two dependent variables. Independent-samples t-tests were used to examine differences between groups where appropriate, while MANOVA was used to examine the simultaneous effect of the treatment on mathematics motivation and cognitive learning outcomes. Where pretest differences need to be statistically controlled, an appropriate multivariate covariance approach may be used rather than relying solely on posttest comparisons.

The multivariate analysis was conducted because mathematics motivation and cognitive learning outcomes represent complementary dimensions of students' learning. Mathematics motivation reflects an affective

dimension, whereas cognitive learning outcomes reflect students' acquisition and application of mathematical knowledge. Statistical significance was determined using $p < 0.05$. Effect-size estimates should also be reported to indicate the practical magnitude of the treatment effect, rather than relying only on statistical significance.

3. RESULTS AND DISCUSSION

3.1 Baseline Conditions of the Experimental and Control Groups

Before the implementation of the learning intervention, both groups were assessed to determine their initial mathematics motivation and cognitive learning outcomes. Each group consisted of 30 Grade 2 students. The results showed that the two groups had relatively similar baseline conditions. The experimental group obtained a total mathematics motivation score of 1,926, with a mean score of 64.20. The cognitive learning pretest produced a total score of 1,975, with a mean of 65.83. Based on the predetermined KKTP of 75, only 2 students (6.67%) achieved the minimum mastery criterion, while 28 students (93.33%) remained below the criterion. The control group showed a total mathematics motivation score of 1,896, with a mean of 63.20. The mean cognitive learning pretest score was 65.00, with a total score of 1,950. Only 1 student (3.33%) achieved the KKTP, whereas 29 students (96.67%) had scores below 75.

Table 5. Baseline Mathematics Motivation and Cognitive Learning Outcomes

Variable	Experimental Group (n=30)	Control Group (n=30)
Total motivation score	1,926	1,896
Mean motivation score	64.20	63.20
Highest motivation score	75	75
Lowest motivation score	55	55
Total cognitive pretest score	1,975	1,950
Mean cognitive pretest score	65.83	65.00
Highest cognitive score	75	75
Lowest cognitive score	55	55
Students achieving KKTP	2 (6.67%)	1 (3.33%)
Students below KKTP	28 (93.33%)	29 (96.67%)

The baseline findings indicate that mathematics motivation and cognitive learning outcomes were relatively low in both groups. The mean motivation scores were 64.20 and 63.20 for the experimental and control groups, respectively, while the mean cognitive pretest scores were 65.83 and 65.00. Both means were below the predetermined KKTP of 75. These findings indicate that the students entered the intervention with substantial room for improvement in both motivational and cognitive dimensions.

4.2 Changes in Mathematics Motivation

Following the implementation of the learning intervention, mathematics motivation increased in both groups. In the experimental group, the mean motivation score increased from 64.20 at baseline to 69.13 at the first post-intervention measurement and subsequently to 79.10 at the second measurement. In the control group, the mean motivation score increased from 63.20 at baseline to 68.40 at the first measurement and to 76.40 at the second measurement.

Table 6. Development of Mathematics Motivation

Measurement Stage	Experimental Group	Control Group	Difference
Baseline/Pretest	64.20	63.20	1.00
Measurement 1	69.13	68.40	0.73
Measurement 2	79.10	76.40	2.70
Baseline → Measurement 2	+14.90	+13.20	+1.70

The experimental group demonstrated an absolute increase of 14.90 points from baseline to the second measurement, while the control group increased by 13.20 points. Thus, although both groups showed improvement, the experimental group recorded a slightly greater descriptive increase.

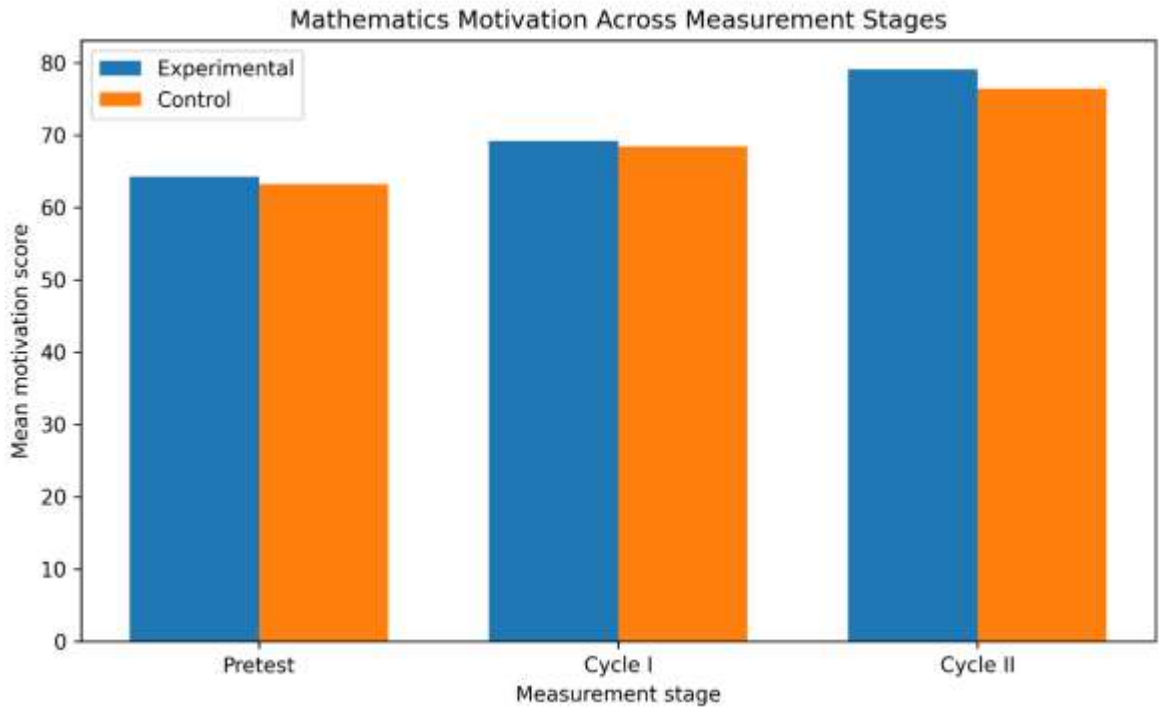


Figure 1. Mathematics Motivation Across Measurement Stages

4.3 Development of Cognitive Learning Outcomes

The cognitive learning results also demonstrated improvement across the measurement stages. In the experimental group, the mean cognitive score increased from 65.83 at baseline to 69.66 at the first measurement and then to 83.33 at the second measurement. In the control group, the mean cognitive score increased from 65.00 at baseline to 69.50 at the first measurement and to 77.46 at the second measurement.

Table 7. Development of Cognitive Learning Outcomes

Measurement Stage	Experimental Group	Control Group	Difference
Baseline/Pretest	65.83	65.00	0.83
Measurement 1	69.66	69.50	0.16
Measurement 2	83.33	77.46	5.87
Baseline → Measurement 2	+17.50	+12.46	+5.04

Descriptively, the experimental group showed a greater increase in cognitive learning scores than the control group. The experimental group increased by 17.50 points from baseline to the second measurement, compared with an increase of 12.46 points in the control group. At the second measurement, the experimental group also obtained a higher mean cognitive score than the control group (83.33 versus 77.46).

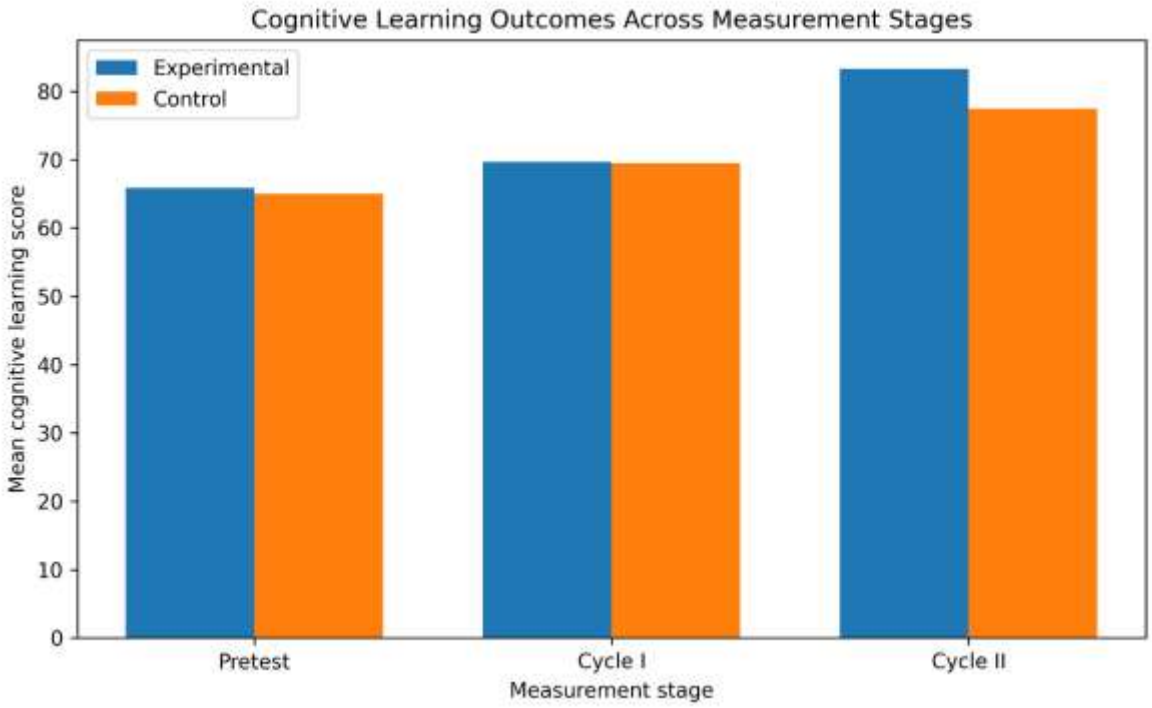


Figure 2. Cognitive Learning Outcomes Across Measurement Stages

4.4 Learning Mastery Based on the KKTP

The proportion of students achieving the predetermined KKTP of 75 also increased across the measurement stages. At baseline, only 6.67% of the experimental group and 3.33% of the control group achieved the criterion. At the first measurement, the proportion of students achieving the KKTP increased to 43.33% in both groups. At the second measurement, all students in both groups achieved the minimum criterion.

Table 4. Percentage of Students Achieving the KKTP

Measurement Stage	Experimental Group	Control Group
Baseline/Pretest	2/30 (6.67%)	1/30 (3.33%)
Measurement 1	13/30 (43.33%)	13/30 (43.33%)
Measurement 2	30/30 (100%)	30/30 (100%)

The experimental group therefore showed an increase in mastery from 6.67% at baseline to 43.33% at the first measurement and 100% at the second measurement. The control group showed a similar progression, increasing from 3.33% to 43.33% and subsequently to 100%.

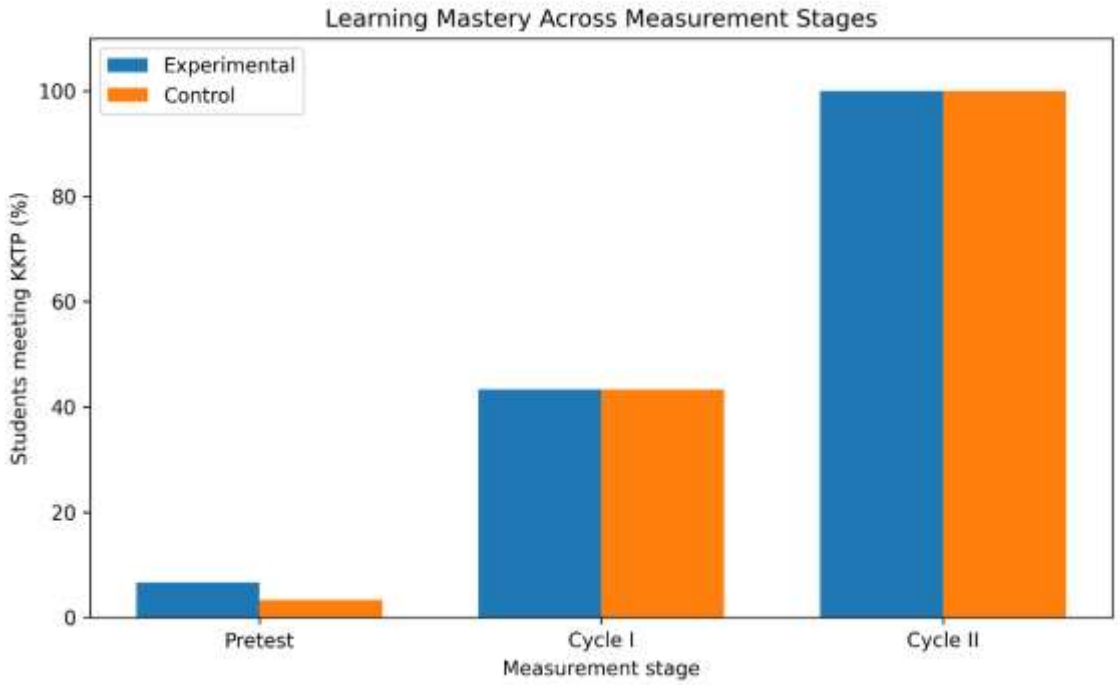


Figure 3. Percentage of Students Achieving the KKTP

4.5 Comparison of Highest and Lowest Cognitive Scores

The distribution of the highest and lowest cognitive scores also changed across the measurement stages. In the experimental group, the highest score increased from 75 at baseline to 80 at the first measurement and 85 at the second measurement. The lowest score increased from 55 at baseline to 55 at the first measurement and subsequently to 80 at the second measurement. In the control group, the highest score increased from 75 at baseline to 80 at the first measurement and was 78 at the second measurement. The lowest score increased from 55 at baseline and at the first measurement to 76 at the second measurement.

Table 5. Highest and Lowest Cognitive Scores

Measurement Stage	Experimental Highest	Experimental Lowest	Control Highest	Control Lowest
Baseline/Pretest	75	55	75	55
Measurement 1	80	55	80	55
Measurement 2	85	80	78	76

The most notable descriptive change occurred in the minimum scores. By the second measurement, the lowest score in the experimental group was 80, while the lowest score in the control group was 76. This pattern indicates that the lower-performing students also demonstrated substantial improvement by the final measurement.

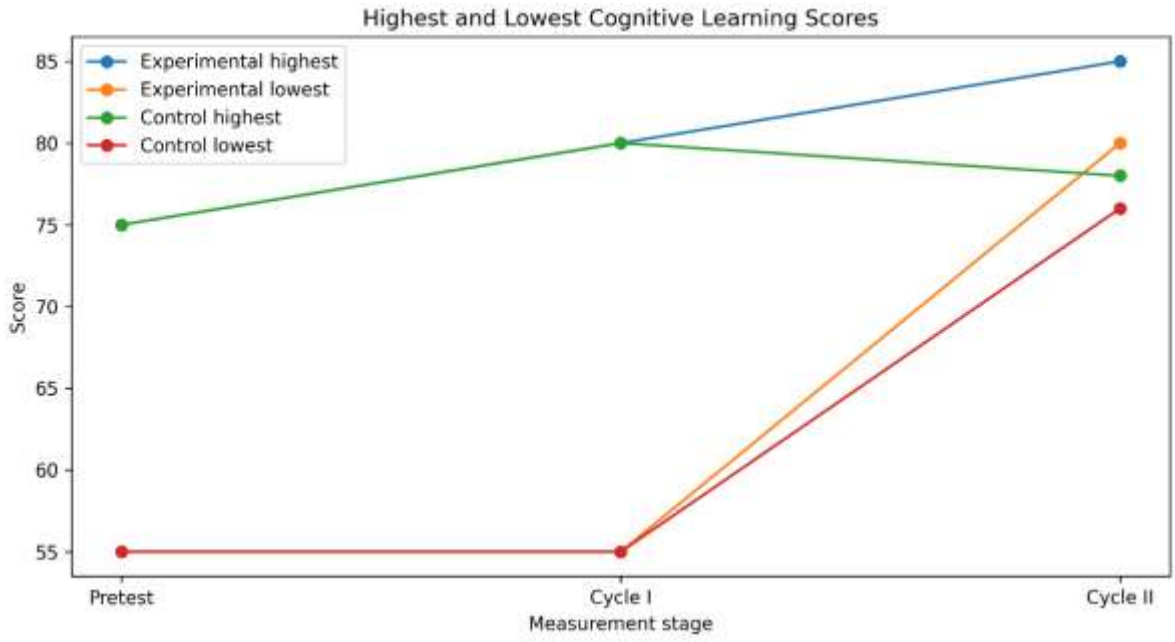


Figure 4. Highest and Lowest Cognitive Scores

4.6 Overall Descriptive Comparison

The overall descriptive results are summarized in Table 6. Both groups demonstrated improvement in mathematics motivation and cognitive learning outcomes over the measurement stages. However, the experimental group showed a greater absolute increase from baseline to the second measurement for both outcomes.

Table 6. Overall Change from Baseline to the Second Measurement

Outcome	Experimental Baseline	Experimental Final	Experimental Increase	Control Baseline	Control Final	Control Increase
Mathematics motivation	64.20	79.10	+14.90	63.20	76.40	+13.20
Cognitive learning outcomes	65.83	83.33	+17.50	65.00	77.46	+12.46
KKTP mastery	6.67%	100%	+93.33 pp	3.33%	100%	+96.67 pp

Overall, the descriptive findings show that the experimental group achieved a higher final mean mathematics motivation score and a higher final mean cognitive learning score than the control group. The largest between-group descriptive difference was observed in cognitive learning outcomes, where the final mean score of the experimental group was 83.33 compared with 77.46 in the control group. Mathematics motivation also showed a higher final mean in the experimental group (79.10) than in the control group (76.40). However, the mastery percentage reached 100% in both groups at the final measurement. Therefore, the mastery criterion alone does not distinguish the two groups at the final stage. The mean scores and the magnitude of improvement provide more informative descriptive comparisons between the two treatment conditions.

The findings indicate that Interactive Digital Demonstration through Ruang Murid was associated with positive development in both mathematics motivation and cognitive learning outcomes among Grade 2 students. At baseline, the two groups showed relatively comparable conditions, with mean mathematics motivation scores of 64.20 in the experimental group and 63.20 in the control group, while the mean cognitive scores were 65.83 and 65.00, respectively. Both cognitive means were below the predetermined KKTP of 75, indicating that students entered the intervention with considerable room for improvement. Following the learning intervention, the experimental group reached a mean mathematics motivation score of 79.10 and a cognitive learning score of 83.33, compared with 76.40 and 77.46 in the control group. The experimental group therefore demonstrated a larger descriptive increase in cognitive outcomes (+17.50) than the control group (+12.46), as well as a slightly larger increase in mathematics motivation (+14.90 versus +13.20). These findings suggest that the integration of digital resources into demonstration-based instruction may provide additional learning support beyond conventional demonstration, particularly for children's cognitive engagement with mathematical concepts. However, because the available results do not report inferential significance or effect-size estimates, these differences should be

interpreted as descriptive evidence rather than definitive evidence of a statistically significant treatment effect. From a pediatric and child-development perspective, the improvement in cognitive learning outcomes observed in this study is relevant to the developmental characteristics of children in the early primary school period. At this age, children are undergoing substantial development in cognitive processes, including attention, working memory, information processing, reasoning, and problem-solving. Children's learning is still strongly supported by concrete experiences, visual representations, repetition, and guided interaction with adults [8], [27]. Therefore, mathematics instruction that provides observable demonstrations and progressively connects visual representations with symbolic procedures may be developmentally appropriate for Grade 2 learners. In the present study, the Interactive Digital Demonstration through Ruang Murid provided students with visual and interactive representations while the teacher maintained an active role in explaining concepts, guiding students' attention, correcting misconceptions, and providing feedback. This combination is important from a pediatric-developmental perspective because digital media should not be considered merely as a technological stimulus, but as a learning environment that needs to be aligned with children's cognitive, attentional, and developmental needs [28]. The increase in the experimental group's cognitive score from 65.83 to 83.33 therefore suggests that developmentally responsive digital learning may provide meaningful support for children's mathematical learning, particularly when digital representations are embedded within structured teacher-guided activities.

The present findings are also consistent with previous evidence showing that educational technology can support young children's mathematical development when it is appropriately implemented [29], [30]. A systematic review of 54 studies on educational technology in early mathematics education found evidence that technology-supported learning can enhance mathematical competencies, while emphasizing that teacher support and implementation characteristics are important conditions for effectiveness. This finding corresponds closely with the present intervention, in which the teacher remained responsible for explaining digital representations, guiding interpretation, correcting misconceptions, and providing feedback rather than allowing the digital platform to function independently. The findings also align with recent evidence that technology, when integrated with engaging pedagogical approaches, can support students' motivation and participation in mathematics learning. A 2026 systematic review of joyful mathematics learning reported that technology, worksheets, and game-based learning are frequently incorporated to enhance engagement, although the strength of evidence concerning learning outcomes remains an area requiring further empirical investigation. Thus, the current results extend previous findings by showing that digital resources can be embedded within a structured demonstration sequence rather than being treated as an independent instructional intervention.

An important contribution of this study lies in the intersection between digital pedagogy, developmental appropriateness, mathematics motivation, and cognitive learning outcomes. Previous research has frequently examined educational technology in terms of whether digital media improve achievement or engagement, whereas the present study conceptualizes digital technology as a pedagogical support that operates within teacher-led demonstration. The distinction is important because the results show improvement in both the experimental and control groups, suggesting that demonstration-based instruction itself contributed to learning development, while the additional integration of Ruang Murid was associated with a greater descriptive gain, particularly in cognitive outcomes. The experimental group's final cognitive mean of 83.33 was 5.87 points higher than that of the control group, whereas the corresponding difference in mathematics motivation was 2.70 points. The novelty, therefore, should not be framed simply as "using Ruang Murid," but as demonstrating a developmentally responsive model in which a national digital learning platform is integrated with teacher-guided demonstration and evaluated simultaneously through affective and cognitive learning dimensions. This positioning responds to the research gap identified in the manuscript, namely the limited evidence concerning the integration of Ruang Murid with interactive demonstration for younger primary school children and the simultaneous consideration of mathematics motivation and C1–C4 cognitive outcomes.

The findings have several practical implications for primary mathematics education. First, teachers can use digital platforms such as Ruang Murid as an instructional scaffold rather than as a replacement for teacher interaction. The teacher's role remains particularly important for translating visual or animated representations into mathematical meaning, monitoring children's responses, and providing immediate clarification. Second, digital demonstrations may be particularly useful for supporting children who initially experience difficulty with mathematical representations because they provide opportunities to see procedures and relationships repeatedly and in a more visually accessible form. Third, the findings suggest that evaluation of digital learning for young children should not rely exclusively on final mastery percentages. Although both groups eventually reached 100% mastery according to the KKTP, the mean cognitive scores and magnitude of improvement revealed differences that the mastery criterion alone could not capture. This has implications for classroom assessment because developmental progress among young learners may be better represented through multiple indicators, including motivation, mean achievement, growth from baseline, and performance of initially lower-achieving students.

Several limitations should nevertheless be considered when interpreting these findings. The study involved two intact Grade 2 classes from a single primary school, with 30 students in each group, and students were not individually randomized. Consequently, the findings cannot automatically be generalized to children of

different ages, schools, socioeconomic backgrounds, or learning environments. In addition, both groups received demonstration-based instruction, meaning that the study primarily compares digital-supported demonstration with conventional demonstration rather than digital learning with a completely non-demonstration condition. The available results are also predominantly descriptive; although the method section proposes independent-samples *t*-tests and MANOVA, the manuscript does not yet report the corresponding *p*-values, confidence intervals, or effect sizes. Future studies should therefore employ larger and more diverse samples, include stronger control of baseline differences, report inferential statistics and effect sizes, and investigate whether the observed benefits persist over longer periods. Longitudinal research could also examine whether developmentally appropriate digital demonstration contributes not only to immediate mathematics achievement but also to sustained motivation, conceptual understanding, and broader cognitive development during later primary school years.

3. CONCLUSION

This study examined the implementation of Interactive Digital Demonstration through Ruang Murid in early primary mathematics learning by considering both mathematics motivation and cognitive learning outcomes. The findings showed that both the experimental and control groups experienced improvements across the measurement stages. However, the experimental group demonstrated a greater descriptive increase in mathematics motivation and cognitive learning outcomes. Mathematics motivation increased from 64.20 to 79.10 in the experimental group, while cognitive learning outcomes increased from 65.83 to 83.33. The corresponding increases in the control group were from 63.20 to 76.40 for mathematics motivation and from 65.00 to 77.46 for cognitive learning outcomes. These findings indicate that integrating digital resources into demonstration-based mathematics instruction may provide additional support for children's motivational and cognitive development when digital resources are accompanied by structured teacher guidance. The contribution of this study lies in positioning Ruang Murid not merely as a digital learning platform but as a pedagogical resource integrated into teacher-guided demonstration activities that are responsive to the developmental characteristics of early primary school children. The findings suggest that digital learning for young learners should combine visual and interactive representations with teacher explanation, practice, feedback, and appropriate scaffolding. Nevertheless, the findings should be interpreted as descriptive evidence because inferential statistical results and effect-size estimates are not presented in the current analysis. Future research should involve larger and more diverse samples, stronger experimental controls, and longitudinal investigation to examine whether the observed improvements are sustained and whether developmentally responsive digital demonstration can contribute to longer-term mathematics learning and cognitive development.).

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AUTHOR CONTRIBUTIONS

Conceptualization, K.L. and P.; Methodology, K.L.; Validation, K.L., P. and R.M.; Formal Analysis, K.L.; Investigation, K.L.; Resources, K.L.; Data Curation, K.L.; Writing – Original Draft Preparation, K.L.; Writing – Review & Editing, P. and R.M.; Visualization, K.L.; Supervision, P.; Project Administration, K.L.; Funding Acquisition, K.L. All authors have read and agreed to the published version of the manuscript.

INFORMED CONSENT STATEMENT

Informed consent was obtained from the parents or legal guardians of all students participating in this study. Prior to data collection, the participants and their parents or legal guardians were informed about the purpose, procedures, and educational nature of the study. Participation was voluntary, and the confidentiality of students' identities and research data was maintained throughout the study.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The authors confirm that there were no personal, professional, or financial circumstances that could have influenced the design, implementation, analysis, interpretation, or reporting of this study..

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with language refinement, organization of the manuscript, and improvement of academic wording. After using this tool, the

authors reviewed, verified, and edited the content as needed and take full responsibility for the accuracy, interpretation, and final content of the published work.

REFERENCES

[1] N. Kock and P. Hadaya, "Minimum sample size estimation in PLS-SEM: The inverse square root and gamma-exponential methods," *Inf. Syst. J.*, vol. 28, no. 1, pp. 227–261, Jan. 2018, doi: 10.1111/isj.12131.

[2] E. Moran, J. Kubale, G. Noppert, R. Malosh, and J. Zelner, "Inequality in acute respiratory infection outcomes in the United States: A review of the literature and its implications for public health policy and practice," Apr. 26, 2020. doi: 10.1101/2020.04.22.20069781.

[3] Tanti, D. A. Kurniawan, R. P. Wirman, and R. W. Dari, "Description of student science process skills on temperature and heat practicum," *J. Penelit. Dan Eval. Pendidik.*, vol. 24, no. 1, pp. 88–101, 2020, doi: doi.org/10.21831/pep. v24i1.31194.

[4] P. Kumar *et al.*, "Using empirical science education in schools to improve climate change literacy," *Renew. Sustain. Energy Rev.*, vol. 178, no. May 2022, p. 113232, 2023, doi: 10.1016/j.rser.2023.113232.

[5] A. Mengist Dessie, S. Fenta Feleke, S. Getaye Workie, T. Getinet Abebe, Y. Mossu Chanie, and A. Kassa Yalew, "Prevalence of Skin Disease and Its Associated Factors Among Primary Schoolchildren: A Cross-Sectional Study from a Northern Ethiopian Town," *Clin. Cosmet. Investig. Dermatol.*, vol. 15, no. 4, pp. 791–801, Apr. 2022, doi: 10.2147/CCID.S361051.

[6] R. J. Gestiada, F. Joseph, T. Nestor, and L. Jr, "The 360 ˚ View : Contextualized Virtual Reality Tours as Innovative Teaching Tool in Ecology for Elementary School Students," vol. 6, no. 1, pp. 23–36, 2025, doi: 10.37251/jber.v6i1.1213.

[7] K. Okui, Y. Sawada, and T. Yoshida, "'Wisdom of the Elders' or 'Loss of Experience' as a Mechanism to Explain the Decline in Traditional Ecological Knowledge: A Case Study on Awaji Island, Japan," *Hum. Ecol.*, vol. 49, no. 3, pp. 353–362, 2021, doi: 10.1007/s10745-021-00237-w.

[8] N. Choi, S. Kang, H. J. Cho, and J. Sheo, "Promoting young children's interest in learning english in efl context: The role of mothers," *Educ. Sci.*, vol. 9, no. 1, 2019, doi: 10.3390/educsci9010046.

[9] A. M. Al Raimi, M. C. Chong, L. Y. Tang, Y. P. Chua, and L. Y. Al Ajeel, "The effect of mobile applications in enhancing asthma knowledge among school children with asthma in Malaysia," *J. Pediatr. Nurs.*, vol. 65, no. 1, pp. 63–71, Jul. 2022, doi: 10.1016/j.pedn.2022.02.012.

[10] L. Zysberg and N. Schwabsky, "School climate, academic self-efficacy and student achievement," *Educ. Psychol.*, vol. 41, no. 4, pp. 467–482, 2021, doi: 10.1080/01443410.2020.1813690.

[11] D. Reinhardt and J. Hurtienne, "Measuring Intuitive Use: Theoretical Foundations," *Int. J. Hum. Comput. Interact.*, vol. 40, no. 10, pp. 2453–2483, 2024, doi: 10.1080/10447318.2023.2166204.

[12] E. N. Setiyani, W. Panomram, and T. Wangdi, "Development of Predict Observe Explain Based Flat Side Building Worksheets to Improve Students' Mathematical Representation Skills," *Interval Indones. J. Math. Educ.*, vol. 2, no. 1, pp. 15–21, 2024, doi: 10.37251/ijome.v2i1.984.

[13] N. Idris, O. Talib, and F. Razali, "Strategies in Mastering Science Process Skills in Science Experiments: a Systematic Literature Review," *J. Pendidik. IPA Indones.*, vol. 11, no. 1, pp. 155–170, 2022, doi: 10.15294/jpii.v11i1.32969.

[14] N.S. Mumthas and Shyma Usman Abdulla, "Substandard performance in mathematical problem solving in physics among higher secondary school students in kerala - an investigation on teacher perceptions and student difficulties," *Issues Ideas Educ.*, vol. 7, no. 1, pp. 35–43, 2019, doi: 10.15415/iie.2019.71005.

[15] N. Kesorn, P. Junpeng, M. Marwiang, K. Pongboriboon, K. N. Tang, and M. Wilson, "Development of an assessment tool for mathematical reading, analytical thinking and mathematical writing," *Int. J. Eval. Res. Educ.*, vol. 9, no. 4, p. 955, Dec. 2020, doi: 10.11591/ijere.v9i4.20505.

[16] A. R. Karim and Arifuddin, "Strategy for Strengthening the Characteristics of Students in Tsanawiyah Madrasa," *Pappaseng Int. J. Islam. Lit. Soc.*, vol. 1, no. 1, pp. 13–22, 2022, doi: 10.56440/pijils.v1i1.6.

[17] M. Papadopoulou *et al.*, "Bedtime routines in Greek families: Characteristics, barriers, and facilitators for establishing and maintaining optimal routines," *Front. Sleep*, vol. 3, no. 1, pp. 133–142, 2024, doi: https://doi.org/10.3389/frsle.2024.1339561.

[18] D. C. Humphrey, M. E. Wechsler, and H. J. Hough, "Characteristics of effective alternative teacher certification programs," *Teach. Coll. Rec.*, vol. 110, no. 1, pp. 1–63, 2008.

[19] M. N. A. Saputro and P. L. Pakpahan, "Mengukur Keefektifan Teori Konstruktivisme dalam Pembelajaran," *J. Educ. Instr.*, vol. 4, no. 1, pp. 24–39, 2021, doi: 10.31539/joeai.v4i1.2151.

[20] L. Verschaffel, S. Schukajlow, J. Star, and W. Van Dooren, "Word problems in mathematics education: a survey," *ZDM - Math. Educ.*, vol. 52, no. 1, pp. 1–16, 2020, doi: 10.1007/s11858-020-01130-4.

[21] P. M. Seloane, S. Ramaila, and M. Ndlovu, "Developing undergraduate engineering mathematics students' conceptual and procedural knowledge of complex numbers using GeoGebra," *Pythagoras*, vol. 44, no. 1, pp. 1–14, 2023, doi: 10.4102/PYTHAGORAS.V44I1.763.

[22] V. Schneider and A. Rohmann, "Arts in Education: A Systematic Review of Competency Outcomes in Quasi-Experimental and Experimental Studies," *Front. Psychol.*, vol. 12, no. April, pp. 1–13, 2021, doi: 10.3389/fpsyg.2021.623935.

[23] D. T. Campbell and J. C. Stanley, *Experimental and Quasi-Experimental Designs for Research*. Boston: MA: Houghton Mifflin, 1963.

[24] P. Nahrisah, R. Somrongthong, N. Viriyautsahakul, P. Viwattanakulvanid, and S. Plianbangchang, "Effect of integrated pictorial handbook education and counseling on improving anemia status, knowledge, food intake, and iron tablet compliance among anemic Pregnant Women in Indonesia: A quasi-experimental study," *J. Multidiscip. Healthc.*, vol. 13, no. 1, pp. 43–52, Jan. 2020, doi: 10.2147/JMDH.S213550.

[25] Ş. Calp, "Peaceful and happy schools: How to build positive learning environments," *Int. Electron. J. Elem. Educ.*, vol.

12, no. 4, pp. 311–320, 2020, doi: 10.26822/iejee.2020459460.
[26] C. L. Dai, M. Sharma, C. C. Chen, E. Yesilyurt, and S. Godbey, "Yoga as an alternative therapy for weight management in child and adolescent obesity: A systematic review and implications for research," *Altern. Ther. Health Med.*, vol. 27, no. 1, pp. 48–55, 2021.
[27] Syaiful, Kamid, D. A. Kurniawan, and P. A. Rivani, "The impact of project-based learning on students' achievement in mathematics," *J. Educ. Res. Eval.*, vol. 5, no. 4, pp. 558–567, 2021, doi: 10.48081/kxbi5168.
[28] F. Dwidarti, Zamzani, and M. Prabowo, "Multimedia-based dance learning in elementary school," *J. Educ. Learn.*, vol. 19, no. 1, pp. 515–521, 2025, doi: 10.11591/edulearn.v19i1.21795.
[29] J. Harlim and I. Belski, "Long-term innovative problem solving skills: Redefining problem solving," *Int. J. Eng. Educ.*, vol. 29, no. 2, pp. 280–290, 2013.
[30] S. Madhankumar, T. A. Prawin Sankar, S. Shibin Thomas, G. Brundhavani, P. Paul, and V. Girishkumar, "Development of Mobile Application Incorporating Augmented Reality for E-education and Training Systems," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1059, no. 1, 2021, doi: 10.1088/1757-899X/1059/1/012016.