Indonesian Journal of Educational Development (IJED)
Volume 7, Issue 2, 2026, pp. 813-829
ISSN: 2722-1059 (Online); ISSN: 2722-3671 (Print)
DOI: https://doi.org/10.59672/ijed.v7i2.6886

Enhancing motivation and mathematics achievement using AI-based Canva tug-of-war game media in deep learning

Ericka Chris Syanti*)[1], Dini Rakhmawati[2], Joko Sulianto[3]
[1]Universitas PGRI Semarang, Semarang, Indonesia; syantic@gmail.com
[2]Universitas PGRI Semarang, Semarang, Indonesia; dinirakmawati@upgris.ac.id
[3]Universitas PGRI Semarang, Semarang, Indonesia; jokosulianto@upgris.ac.id
*)Corresponding author: Ericka Chris Syanti; E-mail addresses: syantic@gmail.com

Article Info

Article history:
Received July 07, 2026
Revised July 13, 2026
Accepted August 04, 2026
Available online August 17, 2026

Keywords: Artificial intelligence, Canva, Deep learning, Learning motivation, Mathematics achievement

Abstract. Low learning motivation and limited conceptual understanding of multiplication and division remain persistent challenges in elementary mathematics education, highlighting the need for innovative and engaging instructional approaches. This study examined the effect of Canva AI-based Mathematics Tug-of-War Media integrated with the Deep Learning approach on elementary students' learning motivation and mathematics achievement. The study employed a quasi-experimental pretest–posttest nonequivalent control group design because intact classes could not be randomly assigned. The population comprised all fifth-grade students of SDN 1 Nglanjuk and SDN Sumberpitu. Using total sampling, all 50 students participated in the study: 26 in the experimental group and 24 in the control group. Data were collected using a mathematics achievement test and a learning motivation questionnaire and analyzed using descriptive statistics, N-Gain, ANOVA, and MANOVA. The experimental group achieved a higher mean N-Gain (0.61 ± 0.08) than the control group (0.35 ± 0.09). MANOVA revealed a significant multivariate effect with a very large effect size (Pillai's Trace = 0.810, $F(2,47) = 100.257$, $p < .001$, Partial Eta Squared = 0.810). This study contributes to mathematics education by introducing an instructional model that integrates AI-assisted Canva media, a traditional Tug-of-War educational game, and a deep learning approach to improve elementary students' learning motivation and mathematics achievement simultaneously. Future research should examine the long-term effectiveness of this instructional model across different mathematics topics, educational levels, and more diverse educational settings.

Introduction

Mathematics is a fundamental subject in elementary education because it develops logical reasoning, problem-solving skills, and conceptual understanding that support lifelong learning (Republik Indonesia, 2003; Pratama et al., 2024). Despite its importance, many elementary students continue to perceive mathematics as difficult and abstract, particularly topics involving multiplication and division (Aprilia & Fitriana, 2022). These learning difficulties often reduce students' motivation to learn, limit their active participation in classroom activities, and ultimately lead to lower mathematics achievement (A. E. P. Nurrawi et al., 2023; Nurwahid, 2021).

The Merdeka Curriculum encourages teachers to create meaningful, student-centred learning experiences supported by innovative instructional media (Kementerian Pendidikan, Kebudayaan, Riset, 2022; Daimah & Suparni, 2023). Effective mathematics instruction promotes cognitive activation, active student participation, and conceptual understanding through appropriate classroom support (Mu et al., 2022). However, mathematics learning in many elementary schools remains predominantly teacher-centred, relying on memorisation and repetitive exercises with limited opportunities for inquiry, collaboration, and active exploration. Consequently, students often become passive learners with lower learning motivation and unsatisfactory mathematics achievement (Adisaka et al., 2022). This discrepancy between curriculum expectations and classroom practice highlights the need for more innovative and engaging instructional approaches.

Game-based learning has emerged as an effective instructional strategy for improving students' engagement, motivation, and conceptual understanding in mathematics. By integrating educational games into classroom instruction, students actively participate in problem-solving, collaboration, and critical thinking rather than passively receiving information (Bado, 2022). Recent systematic reviews further demonstrate that digital game-based learning consistently enhances students' mathematical understanding, higher-order thinking skills, and classroom engagement across different educational contexts (Hussein et al., 2022; Dan et al., 2024). Meta-analytic evidence also indicates that game-assisted mathematics learning positively affects students' higher-order thinking skills by promoting conceptual reasoning and meaningful mathematical problem-solving (Anggoro et al., 2025). Similarly, digital educational games have been shown to improve students' motivation, participation, and mathematics achievement in elementary classrooms (Hendrawan & Marlina, 2022; Anggraini et al., 2021).

Advances in Artificial Intelligence (AI) have created new opportunities to design more adaptive, interactive, and engaging learning environments. One of the most accessible platforms is Canva AI, which enables teachers to generate instructional materials through AI-assisted features such as text-to-image generation, Magic Design, AI-generated illustrations, and automated visual layouts without requiring advanced design skills (Ogunleye et al., 2024; Kasneci et al., 2023; Jayanti et al., 2025). Recent studies indicate that AI-supported visual media enhance students' conceptual understanding, engagement, and learning experiences by presenting mathematical concepts through meaningful visual representations (Crompton & Burke, 2023; Liu et al., 2025). In mathematics education, Canva AI has also been reported to improve mathematical literacy, self-regulated learning, and conceptual understanding by supporting interactive, visually rich instructional materials (Pratiwi & Subekti, 2026; Hariyadi et al., 2026). Nevertheless, most previous studies have employed Canva primarily as a presentation or content-design tool. Empirical evidence on integrating Canva AI with collaborative game-based learning and the Deep Learning approach in elementary mathematics classrooms remains limited.

The Deep Learning approach emphasizes meaningful, mindful, and joyful learning by engaging students in inquiry, collaboration, reflection, and authentic problem-solving rather than passive knowledge acquisition (Mutmainnah et al., 2021). Through these learning experiences, students actively construct conceptual understanding while developing higher-order thinking skills and meaningful mathematical reasoning. Recent studies have consistently reported that the Deep Learning approach improves students' conceptual understanding, classroom engagement, learning motivation, and mathematics achievement (Barokah & Mahmudah, 2025; Asmi & Wijayanto, 2025). Despite these positive findings, previous studies have generally examined Deep Learning, AI-assisted instructional media, and game-based learning separately. Limited empirical evidence has investigated integrating these three instructional components into a single learning model for elementary mathematics education.

Preliminary observations conducted at SD Negeri 1 Nglanjuk indicated that mathematics instruction on multiplication and division remained predominantly teacher-centred, relying mainly on lectures and repetitive exercises with limited use of interactive instructional media. Consequently, students tended to memorize procedures rather than develop conceptual understanding and actively participate in classroom learning. Achievement records showed that only 18 of 26 fifth-grade students (69.3%) achieved the Minimum Mastery Criterion (KKM), while 8 students (30.7%) failed to meet the expected standard, particularly in multiplication and long-division procedures. These findings suggest that limited student engagement and the lack of interactive instructional media contributed to low learning motivation and mathematics achievement, highlighting the need for more innovative, collaborative, and technology-enhanced instructional approaches.

Previous studies have demonstrated the effectiveness of Canva-based instructional media, digital game-based learning, and the Deep Learning approach in improving mathematics learning. However, researchers have generally investigated these instructional components independently or focused on a single learning outcome, such as learning motivation, classroom engagement, or mathematics achievement (Hussein et al., 2022; Dan et al., 2024). Recent reviews have also emphasized the need to integrate emerging Artificial Intelligence technologies with collaborative game-based learning and meaningful pedagogical approaches, particularly in elementary mathematics education (Dan et al., 2024; Ogunleye et al., 2024). To address this gap, the present study developed Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach. Unlike previous studies, this instructional model combines AI-assisted Canva features, collaborative game-based learning, and Deep Learning pedagogy into a unified instructional framework designed to improve both students' learning motivation and mathematics achievement simultaneously. Accordingly, this study contributes empirical evidence toward the development of AI-enhanced, game-based instructional models for elementary mathematics education.

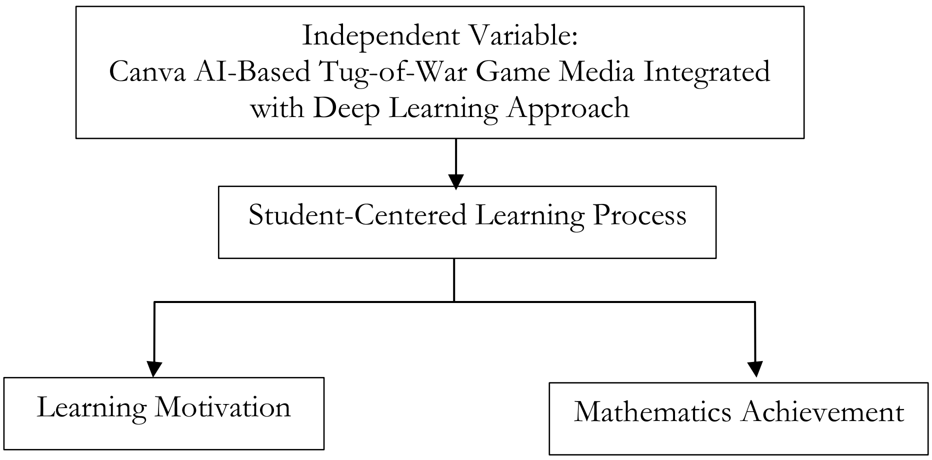

Image 1. Conceptual Framework of the Study

Image 1 presents the study's conceptual framework. It illustrates the integration of Canva AI-Based Mathematics Tug-of-War Media and the Deep Learning approach to promote student-centred mathematics learning and improve students' learning motivation and mathematics achievement.

Based on the identified research gap, this study addresses the following research questions: (1) Does the proposed instructional model significantly improve elementary students' learning motivation compared with conventional instruction? (2) Does the proposed instructional model significantly improve students' mathematics achievement compared with conventional instruction? (3) Does the proposed instructional model simultaneously affect both learning motivation and mathematics achievement? Accordingly, this study proposes the following hypotheses: H_0: There is no significant difference in students' learning motivation and mathematics achievement between the experimental and control groups. H_1: Students taught using Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach demonstrate significantly higher learning motivation and mathematics achievement than those receiving conventional instruction.

Therefore, this study aims to examine the effectiveness of Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach in improving elementary students' learning motivation and mathematics achievement. The findings are expected to contribute empirical evidence for the development of AI-enhanced game-based mathematics instruction and provide practical guidance for teachers in designing technology-supported, student-centred learning environments.

Method

Research Design

This study employed a quantitative quasi-experimental design with a non-equivalent control group design (Creswell & Creswell, 2017; Shadish et al., 2002). Intact classrooms served as the experimental and control groups because random assignment was impractical. The design enabled pre-test and post-test comparisons of students' learning motivation and mathematics achievement to evaluate the effectiveness of Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach.

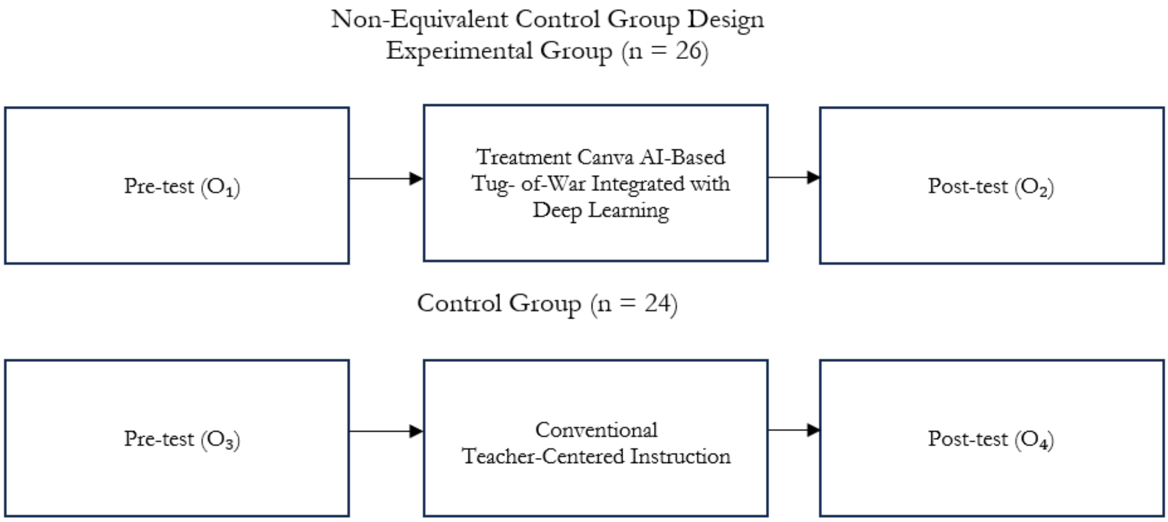

Image 2. Non-equivalent Control Group Design

Image 2 presents the overall procedure. O_1 and O_3 denote the pre-test, whereas O_2 and O_4 denote the post-test measuring students' learning motivation and mathematics achievement. The experimental group received Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach (X), while the control group received conventional teacher-centered instruction. Both groups completed identical pre-tests and post-tests.

Research Setting, Participants, and Sampling Technique

The study was conducted during the second semester of the 2025/2026 academic year at SD Negeri 1 Nglanjuk and SD Negeri Sumberpitu, Blora Regency, Indonesia. The participants comprised 50 fifth-grade students (26 experimental; 24 control). We used purposive sampling because both schools implemented the Merdeka Curriculum and had comparable mathematics learning environments. Baseline equivalence was confirmed using One-Way ANOVA, indicating no significant differences in learning motivation ($F(1,48) = 0.000$, $p = .992$) or mathematics achievement ($F(1,48) = 0.014$, $p = .906$). Levene's test also confirmed homogeneity of variance ($p > .05$). Therefore, the study analyzed learning improvement using N-Gain, followed by One-Way ANOVA and MANOVA.

Research Procedures

The study consisted of four stages: preparation, pre-test, treatment, and post-test. During preparation, the researcher developed the Canva AI-based Mathematics Tug-of-War Media, lesson plans, and research instruments, which experts validated and the researcher pilot-tested before data collection. After obtaining research permission, both groups completed a pre-test consisting of a 20-item mathematics achievement test and a 25-item learning motivation questionnaire.

The intervention was implemented over four meetings (2 × 35 minutes each). The experimental group learned through Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach, whereas the control group received conventional teacher-centred instruction. The media incorporated AI-assisted visual design, interactive game mechanics, and immediate feedback to promote collaborative learning and engagement in multiplication and division.

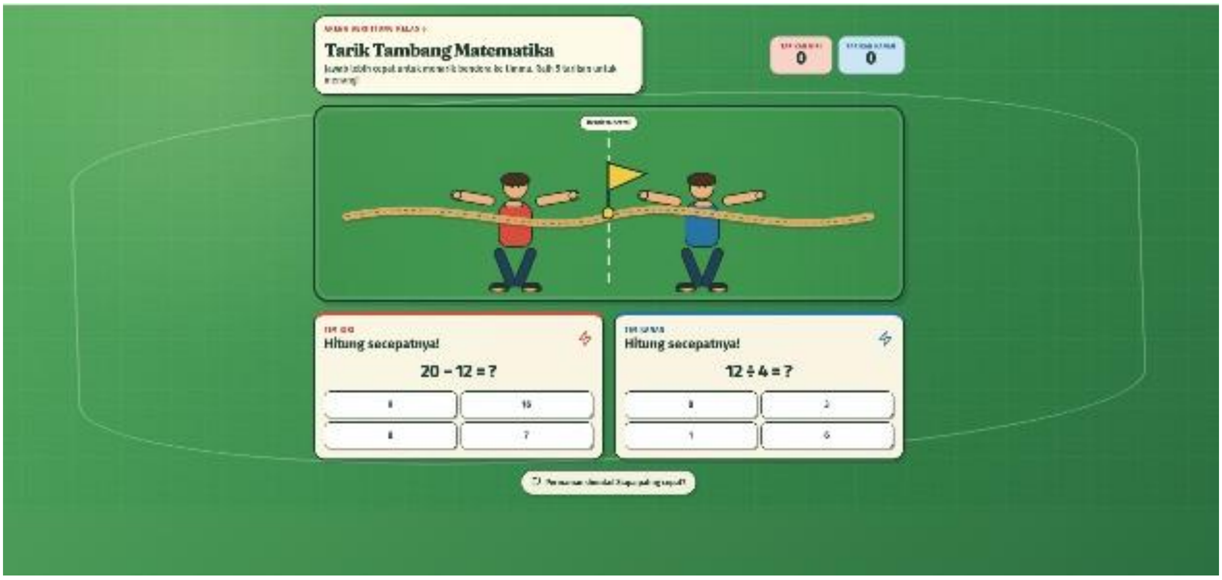

Image 3. Main interface of the Canva AI-Based Mathematics Tug-of-War Media

Image 3 illustrates the Canva AI-Based Mathematics Tug-of-War Media used in the experimental group. The media combines AI-assisted visual design, interactive game mechanics, and immediate feedback to support collaborative learning and conceptual understanding of multiplication and division.

The instructional activities followed five stages based on the Deep Learning approach: (1) *Orientation*, in which the teacher introduced contextual problems, learning objectives, and game procedures to activate prior knowledge; (2) *Inquiry*, where students collaboratively solved multiplication and division problems and constructed conceptual understanding; (3) *Collaboration*, in which the Tug-of-War game promoted teamwork, discussion, and active participation; (4) *Reflection*, where students evaluated their learning with teacher feedback; and (5) *Evaluation*, through formative assessments conducted throughout the lessons.

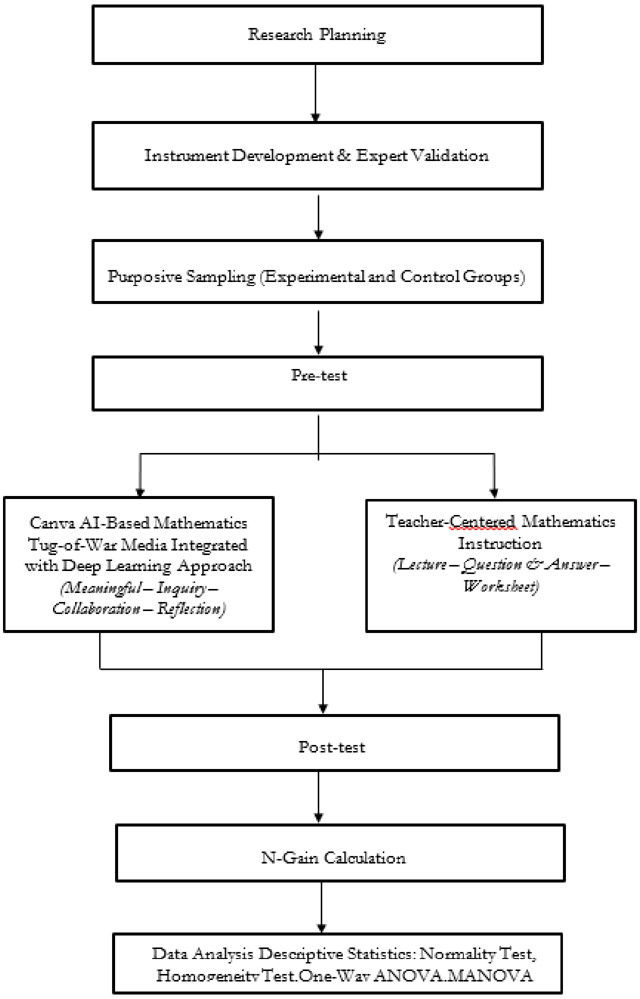

Image 4. Flowchart of the Overall Research Procedure

Image 4 illustrates the overall research procedure, consisting of four stages: preparation, pre-test, treatment, and post-test. During the treatment stage, the experimental group learned using Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach, whereas the control group received conventional teacher-centred instruction. The collected data were analyzed using descriptive statistics, normalized gain (N-Gain), One-Way ANOVA, and MANOVA.

Research Instruments

Data were collected using a mathematics achievement test and a learning motivation questionnaire administered before and after the intervention. The achievement test was conducted under identical procedures in both groups, followed by the motivation questionnaire. All data were coded, checked, and analyzed using IBM SPSS Statistics.

The mathematics achievement test blueprint ensured alignment with the learning objectives and cognitive indicators of multiplication and division. A 20-item multiple-choice test measured mathematics achievement and covered Grade V multiplication and division concepts. Correct answers were scored 1, incorrect answers 0, and total scores were converted to a 0–100 scale for analysis.

Table 1. Blueprint of the Mathematics Achievement Test

No	Learning Material	Learning Indicator	Cognitive Level	Number of items
1	Whole-number division	Determine the correct result of whole-number division in problem-solving situations.	C1 (Remembering)	1
2	Whole-number multiplication	Determine the correct multiplication operation involving whole numbers.	C1 (Remembering)	2
3	Multiplication and division operations	Identify the relationship between multiplication and division operations.	C2 (Understanding)	3, 6
4	Mathematical operations in game contexts	Draw conclusions based on game score data.	C2 (Understanding)	4
5	Distributive property of multiplication	Determine the correct multiplication operation.	C2 (Understanding)	5
6	Whole-number multiplication and division	Calculate scores or operation results within the Mathematics Tug-of-War game context.	C3 (Applying)	7, 8, 9, 10, 11
7	Multiplication strategies	Determine the most appropriate multiplication strategy.	C4 (Analyzing)	12, 13, 15
8	Division strategies	Determine the most appropriate division strategy.	C4 (Analyzing)	16, 17
9	Decimal multiplication	Determine the correct placement of the decimal point in multiplication results.	C5 (Evaluating)	18, 19
10	Decimal division	Determine the correct result of decimal division.	C5 (Evaluating)	14
11	Mathematical problem solving	Select the most efficient problem-solving strategy.	C5 (Evaluating)	20
Total				20

The questionnaire blueprint ensured adequate coverage of both intrinsic and extrinsic learning motivation. The questionnaire measured students' learning motivation using a 25-item instrument adapted from established motivation theories. The instrument employed a four-point Likert scale (1 = Strongly Disagree to 4 = Strongly Agree) to assess intrinsic and extrinsic motivation, including learning interest, persistence, participation, self-confidence, and responsibility.

Table 2. Blueprint of the Learning Motivation Questionnaire

No	Sub-variable	Indicator	Favorable Items	Unfavorable Items	Total Items
1	Desire to Succeed	Students' desire to achieve the best performance in mathematics learning.	1, 2, 3	4	4
2	Learning Drive and Needs	Students' awareness of the importance of understanding multiplication and division concepts.	5, 6, 7	8	4
3	Future Expectations and Aspirations	Students' belief that mathematics competence is beneficial for their future.	9, 10, 11	12	4

No	Sub-variable	Indicator	Favorable Items	Unfavorable Items	Total Items
4	Learning Appreciation	Students' enthusiasm for appreciation and feedback received during learning.	13, 14, 15	16	4
5	Interesting Learning Activities	Students' interest in learning through the Canva AI-Based Mathematics Tug-of-War Media.	17, 18, 19	20	4
6	Conducive Learning Environment	Students' comfort and active participation in collaborative learning activities.	21, 22, 23	24, 25	5
Total			18	7	25

Content Validity

Both instruments underwent expert review before pilot testing. An educational psychology expert and a mathematics education expert evaluated the learning motivation questionnaire. The experts assessed item relevance, clarity, language, and alignment with the research objectives, and the researchers incorporated their feedback into the final instruments.

Construct Validity

The instruments were pilot-tested with students who had characteristics similar to the study participants. We assessed construct validity using the Corrected Item–Total Correlation (CITC), and evaluated reliability using Cronbach's alpha. Table 3 presents the results.

Table 3. Validity Results

Instrument	Number of Items	CITC Range	Cronbach's Alpha	Decision
Learning Motivation Questionnaire	25	0.494–0.804	0.954	Valid and Reliable
Mathematics Achievement Test	20	0.395–0.699	0.908	Valid and Reliable

Table 3 presents the validity and reliability of the research instruments. The learning motivation questionnaire produced Corrected Item–Total Correlation (CITC) values of 0.494–0.804, while the mathematics achievement test ranged from 0.395–0.699, indicating satisfactory construct validity (CITC > 0.30). Cronbach's alpha coefficients were 0.954 and 0.908, respectively, demonstrating excellent reliability. Therefore, both instruments were suitable for the main study. Pilot Testing: We pilot-tested the instruments with students with characteristics similar to the study participants. The results confirmed that all items met the required validity and reliability criteria.

Data Analysis

We analyzed the data using IBM SPSS Statistics. Descriptive statistics (mean, standard deviation, minimum, and maximum) summarized learning motivation and mathematics achievement. We examined normality and homogeneity assumptions using the Shapiro–Wilk and Levene's tests. We tested baseline equivalence using One-Way ANOVA, followed by N-Gain analysis, One-Way ANOVA, and MANOVA to evaluate the intervention. Statistical significance was set at $p < .05$, and Partial Eta Squared (η^2) was reported as the effect size.

Ethical Considerations

The researchers obtained research permission from the principals of both schools before data collection. Participation was voluntary, teachers were informed of the research procedures, and all data were anonymized to ensure confidentiality in accordance with educational research ethics.

Results and Discussion

Baseline Equivalence of the Experimental and Control Groups

Table 4. Baseline Equivalence of the Experimental and Control Groups

Variable	Group	N	Mean	SD	F	p	Interpretation
Learning Motivation (Pre-test)	Experimental	26	50.85	4.679	0.000	0.992	Equivalent
	Control	24	50.83	4.650			
Mathematics Achievement (Pre-test)	Experimental	26	51.54	10.842	0.014	0.906	Equivalent
	Control	24	51.88	8.946			

To examine baseline equivalence, we performed a one-way ANOVA on pre-test scores for learning motivation and mathematics achievement. As shown in Table 4, no significant differences were found between the experimental and control groups in learning motivation $(F(1,48) = 0.000, p = .992)$ or mathematics achievement $(F(1,48) = 0.014, p = .906)$. These findings indicate that both groups were comparable prior to the instructional intervention, allowing subsequent differences to be attributed to the instructional treatment.

Descriptive Statistics

This section presents the results of descriptive and inferential statistical analyses performed to investigate how Canva AI-Based Mathematics Tug-of-War Media, combined with the Deep Learning approach, influences students' learning motivation and mathematics achievement.

Table 5. Descriptive Statistics of Learning Motivation and Mathematics Achievement

Group	Variable	N	Mean	SD
Experimental	Pre-test Learning Motivation	26	50.85	4.679
	Post-test Learning Motivation	26	80.04	4.413
	Pre-test Mathematics Achievement	26	51.54	10.842
	Post-test Mathematics Achievement	26	81.35	10.350
Control	Pre-test Learning Motivation	24	50.83	4.650
	Post-test Learning Motivation	24	62.88	3.518
	Pre-test Mathematics Achievement	24	51.88	8.946
	Post-test Mathematics Achievement	24	70.83	8.165

Table 5 presents the descriptive statistics of students' learning motivation and mathematics achievement before and after the instructional intervention. Consistent with the baseline equivalence results (Table 4), both groups showed comparable pre-test scores for both variables.
After the intervention, the experimental group demonstrated greater improvements than the control group. Learning motivation increased from 50.85 to 80.04 in the experimental group, compared with 50.83 to 62.88 in the control group. Likewise, mathematics achievement increased from 51.54 to 81.35 in the experimental group, whereas it improved from 51.88 to 70.83 in the control group. These findings indicate that mathematics instruction using Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach was associated with

greater improvements in both learning motivation and mathematics achievement than conventional instruction.

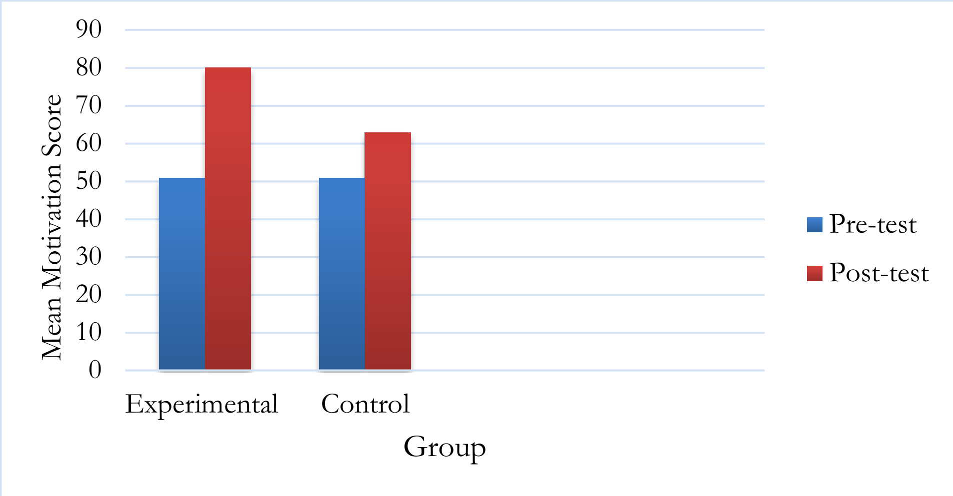

Image 4. Mean Pre-test and Post-test Scores of Learning Motivation

Image 4 illustrates the changes in students' motivation to learn before and after the instructional intervention. Both groups showed improved motivation; however, the experimental group exhibited a markedly greater increase than the control group, indicating the effectiveness of Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach.

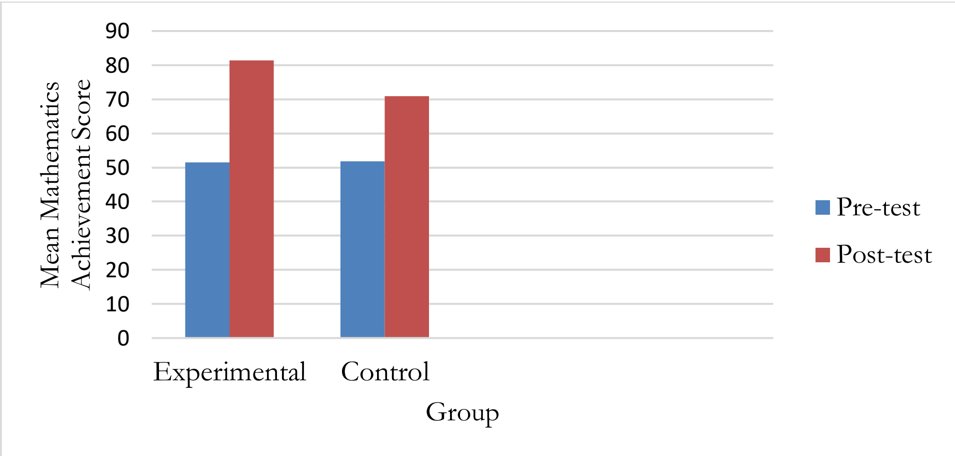

Image 5: Mean Pre-test and Post-test Scores of Mathematics Achievement

Image 5 illustrates the changes in students' mathematics achievement before and after the instructional intervention. Both groups showed improved achievement; however, the experimental group demonstrated a markedly greater increase than the control group, indicating the effectiveness of Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach in enhancing mathematics achievement.

Assumption Testing

Prior to MANOVA, the assumptions of normality, homogeneity of variance, and equality of covariance matrices were examined.

Normality Test

The Shapiro–Wilk test was used because each group comprised fewer than 50 participants. As shown in Table 6, all variables had significance values greater than .05, indicating that the assumption of normality was met.

Table 6. Shapiro–Wilk Test of Normality

Variable	Group	Statistic	Sig.	Decision
Pre-test Learning Motivation	Experimental	0.970	0.635	Normal
	Control	0.963	0.501	Normal
Post-test Learning Motivation	Experimental	0.939	0.128	Normal
	Control	0.923	0.068	Normal
Pre-test Mathematics Achievement	Experimental	0.965	0.212	Normal
	Control	0.957	0.254	Normal
Post-test Mathematics Achievement	Experimental	0.947	0.226	Normal
	Control	0.952	0.105	Normal

We used the Shapiro–Wilk test because each group had fewer than 50 participants. As presented in Table 6, all variables met the assumption of normality ($p > .05$), supporting the use of parametric analyses.

Homogeneity Test

Table 7. Levene's Test of Homogeneity of Variance for N-Gain Scores

Test	Sig.	Decision
Box's M	0.245	Homogeneous
Levene (Motivation)	0.545	Homogeneous
Levene (Achievement)	0.072	Homogeneous

Table 7 presents the results of Levene's Test for the N-Gain scores. As both learning motivation ($p = .545$) and mathematics achievement ($p = .072$) showed significance values greater than .05, the assumption of homogeneity of variance was satisfied.

Box's M Test of Equality of Covariance Matrices

Table 8. Box's M Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.	Decision
4.353	1.385	3	530484.255	0.245	Assumption satisfied

Table 8 presents the results of Box's M Test. The significance value ($p = .245$) exceeded the recommended criterion of .001, indicating that the assumption of equality of covariance matrices was satisfied. Therefore, the data met the assumptions required for MANOVA.

N-Gain Analysis

The N-Gain analysis evaluated the effectiveness of the instructional intervention by measuring the extent of improvement in students' learning motivation and mathematics achievement after implementing the Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach.

Table 9. N-Gain Scores of Learning Motivation and Mathematics Achievement

Variable	Group	Mean	SD	Category	N
Learning Motivation	Experimental	0.590	0.101	Moderate	26
	Control	0.237	0.237	Low	24
Mathematics Achievement	Experimental	0.586	0.243	Moderate	26
	Control	0.356	0.285	Moderate	24

As presented in Table 9, the experimental group achieved higher normalized gain (N-Gain) scores than the control group for both learning motivation and mathematics achievement. The experimental group obtained mean N-Gain scores of 0.590 (SD = 0.101) for learning motivation and 0.586 (SD = 0.243) for mathematics achievement, compared with 0.237 (SD = 0.114) and 0.356 (SD = 0.285), respectively, in the control group. According to Hake (1999) classification, the experimental group demonstrated moderate improvement in both variables, whereas the control group showed low improvement in learning motivation and moderate improvement in mathematics achievement. These findings indicate greater learning improvement following instruction using Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach.

One-Way ANOVA Results

To examine the effect of the instructional intervention on each dependent variable separately, One-Way ANOVA was conducted using the normalized gain (N-Gain) scores. The homogeneity-of-variance assumption was met (Table 7), indicating that the data were appropriate for ANOVA.

Table 10. One-Way ANOVA Results

Dependent Variable	F	Sig.	Interpretation
Learning Motivation (N-Gain)	134.977	< .001	Significant
Mathematics Achievement (N-Gain)	9.469	.003	Significant

As presented in Table 10, significant differences were found between the experimental and control groups for both dependent variables. Learning motivation differed significantly $(F(1,48) = 134.977, p < .001)$, as did mathematics achievement $(F(1,48) = 9.469, p = .003)$. These results indicate that students who learned using Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach improved more than those receiving conventional instruction.

Correlation Analysis

Pearson correlation analysis examined the relationship between improvements in learning motivation and mathematics achievement.

Table 11. Pearson Correlation between Learning Motivation and Mathematics Achievement

Variables	Pearson Correlation (r)	Sig. (2-tailed)	N	Interpretation
N-Gain Learning Motivation × N-Gain Mathematics Achievement	0.379	0.007	50	Positive, moderate, and significant correlation

As presented in Table 11, Pearson correlation analysis revealed a positive and significant relationship between improvements in learning motivation and mathematics achievement $(r = .379, p = .007)$. This result indicates that students with greater increases in learning motivation also tended to achieve greater improvements in mathematics achievement. The significant correlation supports the simultaneous analysis of both dependent variables using MANOVA.

Multivariate Analysis of Variance (MANOVA)

Table 12. Multivariate Analysis of Variance (MANOVA)

Test	Value	F	Sig.	Partial η^2
Learning Motivation	0.810	100.257	0.000	0.810
Mathematics Achievement	0.190	100.257	0.000	0.810

As presented in Table 12, MANOVA revealed a significant multivariate effect of the instructional intervention on learning motivation and mathematics achievement *(Pillai's Trace = 0.810, F = 100.257, p < .001)*. This result indicates that Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach simultaneously influenced both dependent variables. The intervention also produced a large multivariate effect size *(Partial η^2 = 0.810)*, indicating that 81.0% of the variance in the combined dependent variables was associated with the instructional intervention. These findings confirm the effectiveness of the proposed instructional model in improving students' learning motivation and mathematics achievement.

The findings demonstrate that implementing Canva AI-Based Mathematics Tug-of-War Media integrated with the Deep Learning approach significantly improved elementary students' learning motivation and mathematics achievement. MANOVA and follow-up ANOVA confirmed significantly greater learning gains in the experimental group, supported by a large multivariate effect size (Partial η^2 = 0.810). The positive correlation between learning motivation and mathematics achievement (r = .379, p = .007) indicates that increased motivation was associated with greater learning gains, supporting previous evidence that technology-assisted collaborative learning enhances both motivation and academic performance (Anggoro et al., 2025; Harahap et al., 2026; Widana et al., 2023).

The instructional model transformed multiplication and division into interactive, collaborative, and visually meaningful learning experiences. Consistent with Piaget's cognitive development theory and constructivist learning, elementary students develop conceptual understanding more effectively through visual representations, direct experiences, and active knowledge construction (Marinda, 2020; Suparlan, 2019). Accordingly, the Tug-of-War activities encouraged discussion, justification, and evaluation of mathematical solutions rather than procedural memorization. These findings agree with previous studies showing that interactive mathematics media improve conceptual understanding and classroom participation (Adisaka et al., 2022; Handayani et al., 2026; Hariyadi et al., 2026).

The findings further indicate that Artificial Intelligence is most effective when integrated with appropriate pedagogy rather than functioning as a stand-alone technology (Crompton & Burke, 2023; Liu, J. et al., 2025). In this study, Canva AI supported teachers in designing learning activities, while the Deep Learning approach promoted inquiry, collaboration, reflection, and authentic problem-solving (Mutmainnah et al., 2021). These learning experiences strengthened conceptual understanding, higher-order thinking, and classroom engagement, consistent with previous studies (Asmi & Wijayanto, 2025; Barokah & Mahmudah, 2025; Syafitri et al., 2025). They also align with Self-Determination Theory, which emphasizes autonomy, competence, and relatedness Ryan & Deci (2020). Moreover, Pintrich (2003) highlighted the role of motivation in active participation and persistence. Likewise, Expectancy–Value Theory explains students' higher engagement because the learning activities were perceived as meaningful and achievable (Eccles & Wigfield, 2020). Supported by Canva AI, the Mathematics Tug-of-War game promoted discussion, immediate feedback, and collaboration, reinforcing evidence that digital game-based learning improves motivation, engagement, and mathematics achievement (Dan et al., 2024; Hussein et al., 2022; Nurwahid, 2021).

Unlike previous studies that examined Canva, Artificial Intelligence, Deep Learning, or game-based learning separately (Hendrawan & Marlina, 2022). Hendrawan & Marlina (2022); Kasneci et al. (2023); Kharissidqi (2022); Pratiwi & Subekti (2026); Hasibuan et al. (2024), this study integrates these elements into a single instructional model. Canva AI functioned as an instructional design assistant by supporting prompt generation, game organization, and visual planning while teachers retained responsibility for pedagogical decisions. This finding supports recent evidence that AI enhances teaching quality when used to support instructional design rather than replace teachers (Crompton & Burke, 2023; Liu et al., 2025; Ogunleye et al., 2024).

Practically, the proposed model provides an accessible strategy for designing interactive mathematics instruction without requiring advanced technological expertise. By combining Canva AI, collaborative game-based learning, and the Deep Learning approach, teachers can create meaningful, student-centered mathematics learning that aligns with the Merdeka Curriculum's emphasis on collaboration, creativity, critical thinking, and digital technology integration (Daimah & Suparni, 2023).

Despite its promising findings, the study was limited by its small sample, implementation in two schools, focus on multiplication and division, and short intervention period. Future research should examine AI-assisted game-based learning across broader mathematics topics, educational levels, and diverse settings, compare AI-supported instructional media, and investigate long-term effects on mathematical reasoning, problem-solving, self-regulated learning, digital literacy, computational thinking, and culturally responsive mathematics instruction.

Conclusion

This study concludes that integrating Canva AI-Assisted Mathematical Tug-of-War Media with the Deep Learning approach significantly improved elementary students' learning motivation and mathematics achievement compared with conventional instruction. The findings indicate that AI-assisted instructional design, collaborative game-based learning, and meaningful learning effectively enhance both cognitive and affective outcomes. The study contributes theoretically by demonstrating that Artificial Intelligence is most effective as a pedagogical design support rather than an autonomous teaching system. Integrating Canva AI with constructivist learning, Game-Based Learning, and the Deep Learning approach extends current knowledge on AI-enhanced pedagogy by showing that technology is more effective when embedded in meaningful, collaborative, and student-centred learning. Practically, the proposed model provides teachers with an accessible framework for designing interactive mathematics instruction using Canva AI while maintaining their central pedagogical role. This study was limited by its small sample, implementation in two elementary schools, focus on multiplication and division, and short intervention period. Future research should examine AI-assisted instructional models across broader mathematics topics, educational levels, and diverse learning contexts, compare different AI platforms, and investigate their long-term effects on mathematics achievement, learning motivation, mathematical reasoning, problem-solving, self-regulated learning, digital literacy, and computational thinking.

Bibliography

Adisaka, K., Margunayasa, I. G., & Gunartha, I. W. (2022). The effect of collaborative learning methods on fifth-grade students' interest and mathematics learning outcomes. *Jurnal Ilmiah Pendidikan Citra Bakti*, *9*(1), 141–152. https://doi.org/10.38048/jipcb.v9i1.670

Anggoro, B. S., Dewantara, A. H., Suherman, S., & Muhammad, R. R., Saraswati, S. (2025). Effect of game-based learning on students' high-order thinking skills in mathematics: A meta-analysis. *Revista de Psicodidáctica (English Ed.)*, *30*(1), 500158. https://doi.org/10.1016/j.psicoe.2024.500158

Anggraini, H. I., Nurhayati, & Kusumaningrum, S. R. (2021). Application of HOTS-based mathematics game learning media using the digital game-based learning (DGBL) method. *Jurnal Pendidikan Indonesia (Japendi)*, *2*(11), 1885–1896.

Aprilia, A., & Fitriana, D. N. (2022). Mindset awal siswa terhadap pembelajaran matematika yang sulit dan menakutkan. *Journal of Elementary Education*, *1*(2), 28–40.

Asmi, Y. K., & Wijayanto, Z. (2025). He effect of the deep learning approach and interactive media based on the Canva digital platform on learning outcomes of area measurement in elementary schools. *Didaktika Dwija Indria*, *13*(2). https://doi.org/10.20961/ddi.v13i2.101285

Bado, N. (2022). Game-based learning pedagogy: A review of the literature. *Interactive Learning Environments*, *30*(5), 936–948. https://doi.org/10.1080/10494820.2019.1683587

Barokah, N., & Mahmudah, U. (2025). Transformation of elementary mathematics learning through deep learning: Strategies to improve motivation and achievement. *Jurnal Ilmiah Matematika, Kebumian Dan Angkasa*, *3*(3), 48–61. https://doi.org/10.62383/bilangan.v3i3.521

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches.* Sage Publications.

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education, 20*(1), 1–22.

Daimah, U. S., & Suparni. (2023). Mathematics learning in the Merdeka Curriculum in preparing students for the Society 5.0 era. *Sepren*, *4*(02), 131–139. https://doi.org/10.36655/sepren.v4i02.888

Dan, N. N., Nga, N. T., & Dung, T. M. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(4), em2423. https://doi.org/10.29333/ejmste/14377

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology, 61*, 101859. https://doi.org/10.1016%2Fj.cedpsych.2020.101859

Hake, R. R. (1999). Analyzing change/gain scores. *Indiana University.*

Handayani, N., Lestari, B., & Suastika, I. K. (2026). Improving mathematics learning outcomes on whole number material through Canva-based interactive media among fifth-grade students. *Jurnal Ilmiah Pendidikan Dasar*, *11*(02). https://doi.org/10.23969/jp.v11i02.49305

Harahap, F. S. W., Simbolon, H. Y., & Fitri, Y. (2026). Effectiveness of Python-based learning on understanding fractions and decimals: An N-Gain analysis. *Jurnal Pendidikan Indonesia (PJPI)*, *4*, 139–156. https://doi.org/10.61930/pjpi.v4i1.1512

Hariyadi, M., Prabowo, A., Avrilianda, D., & Widiarti, N. (2026). A systematic literature review of Canva-assisted interactive learning media development in elementary school mathematics (2021–2026). *Jurnal Kiprah Pendidikan*, *5*(2), 127–137. https://doi.org/10.33578/kpd.v5i2.p127-137

Hendrawan, G. B., & Marlina, R. (2022). Students' perceptions of the use of digital educational games in mathematics learning. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *5*(2), 395. https://doi.org/10.22460/jpmi.v5i2.10288

Hasibuan, N. S., Pulungan, H. R., Azelia, C., Hutabarat, A. P., Nanda, N., & Wahyudi, A. (2024). Development of Mandailing natal folklore teaching materials based on local wisdom of

marsali with the aid of Canva online comics. *Indonesian Journal of Educational Development (IJED)*, *5*(3), 385–393. https://doi.org/10.59672/ijed.v5i3.4106
Hussein, M. H., Ow, S. H., Elaish, M. M., & Jensen, E. O. (2022). Digital game-based learning in K-12 mathematics education: A systematic literature review. *Education and Information Technologies*, *27*(2), 2859–2891. https://doi.org/10.1007/s10639-021-10721-x
Jayanti, M. D. S. D., Kusuma, I. P. I., & Marsakawati, N. P. E. (2025). Digital stories combined with POWER strategy supported by Canva in writing skill and social emotional learning. *Indonesian Journal of Educational Development (IJED)*, *6*(1), 135–147. https://doi.org/10.59672/ijed.v6i1.4655
Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274
Kementerian Pendidikan, Kebudayaan, Riset, dan T. (2022). Ministerial regulation no. 5 of 2022 on graduate competency standards for early childhood education, basic education, and secondary education. In *Permendikbudristek*. https://jdih.kemdikbud.go.id
Kharissidqi, M. F. V. (2022). The application of Canva as effective learning media. *Indonesian Journal Of Education and Humanity*, *2*(4), 108–113. https://ijoehm.rcipublisher.org/index.php/ijoehm/article/view/34
Liu, J., Sun, D., Sun, J., Wang, J., & Yu, P. L. H. (2025). Designing a generative AI-enabled learning environment for mathematics word problem solving in primary schools: Learning performance, attitudes and interaction. *Computers and Education: Artificial Intelligence*, *9*, 100438. https://doi.org/10.1016/j.caeai.2025.100438
Marinda, L. (2020). Jean Piaget's theory of cognitive development and its problems in elementary school-age children. *Journal of Gender Studies*, *13*(1), 116–152. https://annisa.uinkhas.ac.id/index.php/annisa/article/view/26
Mu, J., Bayrak, A., & Ufer, S. (2022). Conceptualizing and measuring instructional quality in mathematics education: A systematic literature review. *In Frontiers in Education*, *7*, 994739. https://doi.org/10.3389/feduc.2022.994739
Mutmainnah, N., Adrias, A., & Zulkarnaini, P. A. (2021). Implementation of the deep learning approach in mathematics learning at school. *Jurnal Ilmiah Pendidikan Dasar*, *10(1)*, 858–871.
Nurrawi, A. E. P., Zahra, A. T., Aulia, D., Greis, G., & Mubarok, S. (2023). Motivasi belajar siswa terhadap hasil belajar matematika (Students' learning motivation and mathematics learning outcomes). *Plusminus: Jurnal Pendidikan Matematika*, *3*(1), 29–38. https://doi.org/10.31980/plusminus.v3i1.1220
Nurwahid, M. (2021). Korelasi antara motivasi belajar siswa dalam pembelajaran online dengan hasil belajar matematika di masa pandemi (The correlation between students' learning motivation in online learning and mathematics learning outcomes during the pandemic). *Jurnal Pendidikan Matematika*, *05*(02), 1127–1137.
Ogunleye, B., Zakariyyah, K. I., Ajao, O., Olayinka, O., & Sharma, H. (2024). A systematic review of generative ai for teaching and learning practice. *Education Sciences*, *14*(6), 636. https://doi.org/10.3390/educsci14060636
Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, *95*(4), 667. https://doi.org/10.1037/0022-0663.95.4.667
Pratama, I. W. R. L., Widana, I. W., & Sudiarta, I. M. (2024). Application of the discovery learning model with process differentiation to improve junior high school students' mathematics learning outcomes. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, *9*(4), 989–1005. https://doi.org/10.31943/mathline.v9i4.632
Pratiwi, Y., & Subekti, F. E. (2026). Integrating Canva-AI and deep learning approaches into interactive mathematics videos to enhance mathematical literacy and self-regulated learning

in vocational education. *Journal of Advanced Sciences and Mathematics Education*, *6*(2). https://doi.org/10.58524/jasme.v6i2.1174
Republik Indonesia. (2003). *Republic of Indonesia. (2003). Law No. 20 of 2003 on the National Education System. State Secretariat of the Republic of Indonesia.* https://sg-link.byteoversea.com/?target=https%3A%2F%2Fperaturan.bpk.go.id%2Fdetails%2F43920%2Fuu-no-20-tahun-2003&scene=im&aid=495671&lang=en-GB
Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860
Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Quasi-experiments: interrupted time-series designs.* Experimental and quasi-experimental designs for generalized causal inference, 1.
Suparlan, S. (2019). Constructivism theory in learning. *Jurnal Keislaman Dan Ilmu Pendidikan*, *1*(2), 79–88.
Syafitri, D. ., Landong, A., & Fadlan, M. . (2025). Development of ethnomathematics-based Canva media on solid geometry using the RME model to improve fifth-grade students' mathematical conceptual understanding at SDN 105331 Punden Rejo. *Jurnal Ilmiah Pendidikan Dasar*, *10*(1). https://doi.org/10.23969/jp.v10i01.23481
Widana, I. W., Suarta, I. M., & Citrawan, I. W. (2019). Work motivation and creativity on the teacher's ability to develop HOTS-based assessments. *International Journal of Social Sciences and Humanities*, *3*(3), 188-200. https://doi.org/10.29332/ijssh.v3n3.378
Widana, I. W., Sumandya, I. W., Citrawan, I. W., Widana, I. N. S., Ibarra, F. P., Quicho, R. F., Delos Santos, M. R. H. M., Velasquez-Fajanela, J. V., & Mukminin, A. (2023). The effect of teachers' responsibility and understanding of the local wisdom concept on teachers' autonomy in developing evaluation of learning based on local wisdom in a special needs school. *Journal of Higher Education Theory and Practice*, *23*(10), 152-167. https://doi.org/10.33423/jhetp.v23i10.6189