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The effect of the gamification-based Teams Games Tournament (TGT) cooperative learning model and students' learning ability on mathematics learning outcomes through learning motivation as a mediating variable in public elementary schools in Serang Regency

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Keywords:
Teams Games Tournament (TGT), gamification, learning ability, learning motivation, mathematics learning outcomes, SEM-PLS.

ABSTRACT

This study examines the effect of the gamification-based Teams Games Tournament (TGT) cooperative learning model and students' learning ability on mathematics learning outcomes through learning motivation as a mediating variable in public elementary schools in Serang Regency, Indonesia. This study employed a quantitative survey approach. The study population consisted of 707 teachers from public elementary schools in Serang Regency, with 260 respondents selected using Slovin's formula through proportional random sampling. Data were collected using a five-point Likert-scale questionnaire and analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS 4. The measurement and structural models were evaluated through measurement model assessment, structural model assessment, and hypothesis testing. The results showed that all proposed hypotheses were supported. The gamification-based Teams Games Tournament (TGT) cooperative learning model had a positive and significant effect on mathematics learning outcomes (β=0.307; t=3.854; p<0.001) and learning motivation (β=0.493; t=5.402; p<0.001). Students' learning ability also had a positive and significant effect on mathematics learning outcomes (β=0.594; t=6.894; p<0.001) and learning motivation (β=0.388; t=3.913; p<0.001). Learning motivation had a positive and significant effect on mathematics learning outcomes (β=0.528; t=4.705; p<0.001). Learning motivation significantly served as a mediating variable in the relationship between the gamification-based Teams Games Tournament (TGT) cooperative learning model and mathematics learning outcomes (β=0.260; t=3.537; p<0.001), as well as in the relationship between students' learning ability and mathematics learning outcomes (β=0.205; t=2.942; p=0.003). The coefficient of determination indicated that the model explained 63.8% of the variance in learning motivation and 78.1% of the variance in mathematics learning outcomes. This study concludes that implementing the gamification-based Teams Games Tournament (TGT) cooperative learning model, supported by students' learning ability, can enhance learning motivation and ultimately improve mathematics learning outcomes.

Article Information

Kata Kunci:
Teams Games Tournament (TGT), gamifikasi, kemampuan belajar, motivasi belajar, hasil belajar matematika, SEM-PLS

ABSTRACT

Penelitian ini bertujuan untuk menganalisis pengaruh penggunaan model pembelajaran kooperatif tipe Teams Games Tournament (TGT) berbasis gamifikasi dan kemampuan belajar siswa terhadap hasil belajar mata pelajaran matematika melalui motivasi belajar sebagai variabel intervening pada SD Negeri di Kabupaten Serang. Penelitian ini dilatarbelakangi oleh masih belum optimalnya hasil belajar matematika siswa sekolah dasar sehingga diperlukan inovasi pembelajaran yang mampu meningkatkan motivasi dan hasil belajar siswa. Penelitian menggunakan pendekatan kuantitatif dengan metode survei. Populasi penelitian berjumlah 707 guru SD Negeri di Kabupaten Serang, sedangkan sampel penelitian sebanyak 260 responden yang ditentukan menggunakan rumus Slovin dengan teknik proportional random sampling. Pengumpulan data dilakukan menggunakan kuesioner skala Likert. Analisis data menggunakan Structural Equation Modeling–Partial Least Squares (SEM-PLS) dengan bantuan perangkat lunak SmartPLS 4. Evaluasi model dilakukan melalui pengujian outer model, inner model, dan pengujian hipotesis. Hasil penelitian menunjukkan bahwa seluruh hipotesis diterima. TGT berbasis gamifikasi berpengaruh positif dan signifikan terhadap hasil belajar matematika (β=0,307; t=3,854; p<0,001) dan motivasi belajar (β=0,493; t=5,402; p<0,001). Kemampuan belajar siswa berpengaruh positif dan signifikan terhadap hasil belajar matematika (β=0,594; t=6,894; p<0,001) dan motivasi belajar (β=0,388; t=3,913; p<0,001). Motivasi belajar berpengaruh positif dan signifikan terhadap hasil belajar matematika (β=0,528; t=4,705; p<0,001). Motivasi belajar juga memediasi secara signifikan pengaruh TGT berbasis gamifikasi terhadap hasil belajar (β=0,260; t=3,537; p<0,001) serta pengaruh kemampuan belajar terhadap hasil belajar (β=0,205; t=2,942; p=0,003). Nilai R^2 motivasi belajar sebesar 0,638 dan R^2 hasil belajar matematika sebesar 0,781. Penelitian menyimpulkan bahwa penerapan TGT berbasis gamifikasi yang didukung kemampuan belajar siswa mampu meningkatkan motivasi belajar sehingga berdampak pada peningkatan hasil belajar matematika.

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1. Introduction

Mathematics is a foundational subject that plays a strategic role in developing logical, systematic, analytical, critical, and creative thinking, as well as problem-solving skills. At the elementary school level, mastery of mathematics provides an important foundation for numeracy, namely, the ability to use concepts of numbers, arithmetic operations, data, measurement, space, patterns, and quantitative reasoning in everyday life.

However, Indonesian students' mathematics achievement continues to present serious challenges. OECD (2023) reported that the PISA 2022 results showed that only 18% of Indonesian students attained at least Level 2 in mathematics, far below the OECD average of 69%. At the elementary school level, the Ministry of Primary and Secondary Education (2025) reported that the proportion of elementary school/madrasah ibtidaiyah/equivalent students who attained minimum numeracy competency increased from 39,04% in 2022 to 45,34% in 2023 and 52,48% in 2024. Despite this increase, nearly half of students have not yet attained minimum numeracy competency.

This issue is relevant to the context of Serang Regency. The Serang Regency Office of Education and Culture (2024) identified improving the quality of educational services as an important agenda in regional education planning. Report card data for mathematics among fourth-grade students at public elementary schools in Serang Regency for the 2025/2026 academic year, as reported in the thesis, show that most students scored between 60 and 62, with an average of approximately 61,54. This condition indicates that mathematics learning outcomes still need to be improved.

One factor presumed to contribute to this condition is a learning process that has not fully encouraged students' active engagement. Mathematics instruction may still be conducted conventionally and in a teacher-centered manner, thereby limiting students' opportunities to discuss, collaborate, play, engage in healthy competition, and construct understanding through learning experiences.

The Teams Games Tournament (TGT) cooperative learning model is one alternative. TGT combines class presentations, group work, academic games, tournaments, and group rewards. Setiana et al. (2025) found that TGT had a positive effect on elementary school students' motivation and mathematics achievement. Through a meta-analysis, Talkhan et al. (2025) also found that cooperative learning had a positive effect on elementary school students' mathematics achievement.

In the context of modern learning, TGT can be strengthened through gamification. Gamification uses game elements such as points, badges, leaderboards, levels, challenges, missions, rewards, and immediate feedback in learning contexts. Through a systematic review and meta-analysis, Ratinho et al. (2026) showed that gamification in mathematics learning is associated with increased student motivation and engagement.

In addition to the learning model, students' learning ability is an important factor affecting learning outcomes. Students' learning ability includes the ability to understand concepts, process information, concentrate, think logically, solve problems, and complete
tasks. Differences in these abilities may lead to differences in learning outcomes among students.

Learning motivation is positioned as a mediating variable because it is a psychological factor that may explain the mechanism through which the learning model and students' learning ability affect learning outcomes. Motivation can encourage students to be active, persistent, make an effort, and persevere when facing learning difficulties.

Previous research still leaves a research gap. Most studies have examined the direct effect of TGT on learning outcomes or investigated gamification separately. Research that simultaneously integrates the gamification-based Teams Games Tournament (TGT) cooperative learning model, students' learning ability, learning motivation as a mediating variable, and mathematics learning outcomes remains limited, particularly in the context of public elementary schools in Serang Regency. The novelty of this study lies in examining direct and indirect relationships among the variables within a single empirical model.

Based on the foregoing, this study aims to analyze the effect of using the gamification-based Teams Games Tournament (TGT) cooperative learning model and students' learning ability on mathematics learning outcomes through learning motivation as a mediating variable in public elementary schools in Serang Regency.

CONCEPTUAL FOUNDATION AND HYPOTHESES

The TGT cooperative learning model places students in group work and academic game activities followed by tournaments. The integration of gamification strengthens engagement through challenges, points, rewards, healthy competition, and feedback. Based on the review in the thesis, this model is expected to affect motivation and learning outcomes.

Students' learning ability is an internal condition that enables students to understand material, process information, concentrate, think logically, and solve problems. Meanwhile, learning motivation is regarded as a drive that directs the intensity, persistence, and continuity of learning activities. Therefore, motivation is positioned as a mediating mechanism between learning and ability variables and learning outcomes.

Hypothesis	Statement
H1	The gamification-based Teams Games Tournament (TGT) cooperative learning model has an effect on mathematics learning outcomes.
H2	The gamification-based Teams Games Tournament (TGT) cooperative learning model has an effect on learning motivation.
H3	Students' learning ability has an effect on mathematics learning outcomes.
H4	Students' learning ability has an effect on learning motivation.
H5	Learning motivation has an effect on mathematics learning outcomes.
H6	The gamification-based Teams Games Tournament (TGT) cooperative learning model has an indirect effect on mathematics learning outcomes through learning motivation.
H7	Students' learning ability has an indirect effect on mathematics learning outcomes through learning motivation.

2. RESEARCH METHODS

This study employed an explanatory quantitative design with a causal relationship model and mediation analysis. The research model positioned the use of the gamification-based Teams Games Tournament (TGT) cooperative learning model (X1) and students' learning ability (X2) as exogenous variables, learning motivation (Z) as a mediating variable, and mathematics learning outcomes (Y) as an endogenous variable.

The study was conducted from April to July 2026 among teachers at public elementary schools in Serang Regency. The study population comprised 707 fourth-grade teachers at public elementary schools. The study sample consisted of 260 respondents, determined using Slovin's formula with a 5% margin of error and proportional random sampling. The respondents had relatively homogeneous characteristics because they were at the same educational level, followed the same curriculum, and received similar mathematics instructional materials.

Data were collected using a five-point Likert-scale questionnaire. The research instrument measured four constructs: the gamification-based Teams Games Tournament (TGT) cooperative learning model with 36 indicators (MPK1–MPK36), students' learning ability with 30 indicators (KB1–KB30), learning motivation with 36 indicators (MB1–MB36), and mathematics learning outcomes with 24 indicators (HBM1–HBM24).

Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS 4. The measurement model evaluation included outer loadings, average variance extracted (AVE), discriminant validity, composite reliability, and Cronbach's alpha. The structural model evaluation included R-square and path coefficient testing. Hypothesis testing was conducted using bootstrapping, with the criteria t-statistic > 1,96 or p < 0,05. Mediation effects were tested through indirect effects.

According to the criteria used in the thesis, outer loadings should ideally be ≥ 0,70, AVE ≥ 0,50, and Cronbach's alpha and composite reliability ≥ 0,70. For the structural model, R^2 values of 0,75, 0,50, and 0,25 are categorized as strong, moderate, and weak, respectively; f^2 values of 0,02, 0,15, and 0,35 are categorized as small, moderate, and large, respectively; and $Q^2 > 0$ indicates predictive relevance.

3. RESEARCH RESULTS

3.1 Data Characteristics and Processing

Of the 172 questionnaires distributed, all were returned. The study was conducted from April to July 2026 and encompassed preparation, instrument development and pilot testing, data collection, data processing, and report preparation. The collected data were analyzed using SEM-PLS with SmartPLS 4.

3.2 Measurement Model Evaluation

The convergent validity test results showed that most indicators had outer loadings above 0,70. For X1, outer loading values ranged from 0,591 to 0,898. For X2, they ranged from 0,739 to 0,849; for Z, from 0,767 to 0,870; and for Y, from 0,766 to 0,863.

The X1 construct included one indicator with a loading of 0,591, which was retained because it remained above 0,50 and did not reduce the overall quality of the construct. The factor loading results table in the thesis identified this indicator as MPK2. The AVE values for all constructs exceeded 0,50.

Construct	Outer Loading Range	AVE	Composite Reliability (rho_a)	Cronbach's Alpha	Conclusion
X1 – Gamification-based TGT	0,591 – 0,898	0,703	0,988	0,988	Valid and reliable
X2 – Students' learning ability	0,739 – 0,849	0,670	0,983	0,983	Valid and reliable
Z – Learning motivation	0,767 – 0,870	0,690	0,987	0,987	Valid and reliable
Y – Mathematics Learning Outcomes	0,766 – 0,863	0,696	0,981	0,981	Valid and reliable

These results indicate that the study constructs met the requirements for convergent validity and reliability. Discriminant validity was also evaluated through cross-loadings and the criteria used in the thesis.

3.3 Goodness of Fit

Index	Saturated Model	Estimated Model
SRMR	0,065	0,065
d_ULS	34,078	34,078
d_G	60,898	60,898
Chi-square	43540,345	43540,345
NFI	0,428	0,428

The SRMR value of 0,065 indicates adequate model fit based on the criteria used in the thesis. The NFI value of 0,428 remains below the ideal value of 0,90 and was noted as a limitation of the model fit indices.

3.4 Coefficient of Determination

Endogenous Variable	R^2	Adjusted R^2	Interpretation
Y – Mathematics Learning Outcomes	0,781	0,778	Strong
Z – Learning Motivation	0,638	0,635	Moderate to strong

An R^2 of 0,638 indicates that 63,8% of the variance in learning motivation can be explained by gamification-based TGT and students' learning ability. An R^2 of 0,781 indicates that 78,1% of the variance in mathematics learning outcomes can be explained by the variables in the research model.

3.5 Direct Effect Hypothesis Testing

Hypothesis	Relationship	β	t-statistic	p-value	Decision
H1	X1 → Y	0,307	3,854	0,000	Accepted
H2	X1 → Z	0,493	5,402	0,000	Accepted
H3	X2 → Y	0,594	6,894	0,000	Accepted
H4	X2 → Z	0,388	3,913	0,000	Accepted
H5	Z → Y	0,528	4,705	0,000	Accepted

3.6 Indirect effect testing

Hypothesis	Mediation path	β indirect effect	t-statistic	p-value	Decision
H6	X1 → Z → Y	0,260	3,537	0,000	Accepted
H7	X2 → Z → Y	0,205	2,942	0,003	Accepted

Thus, all seven research hypotheses were accepted. All relationships were positive and significant.

4. Discussion

4.1 Effect of gamification-based TGT on mathematics learning outcomes

The results showed that gamification-based TGT had a positive and significant effect on mathematics learning outcomes, with β = 0,307, t = 3,854, and p = 0,000. These findings indicate that the better the implementation of this learning model, the higher the mathematics learning outcomes. TGT provides students with opportunities to work in groups, participate in academic games, engage in healthy competition, and receive rewards. The integration of gamification enhances this experience through challenges, points, rewards, and feedback.

These findings are consistent with Setiana et al. (2025), who found an effect of TGT on elementary school students' motivation and mathematics achievement, as well as Simbolon et al. (2025), who demonstrated the effect of the TGT model on the mathematics learning outcomes of fourth-grade students. These results are also consistent with the study by Talkhan et al. (2025) on the effect of cooperative learning on elementary school students' mathematics achievement.

4.2 Effect of gamification-based TGT on learning motivation

Gamification-based TGT had a positive and significant effect on learning motivation, with β = 0,493, t = 5,402, and p = 0,000. These results indicate that learning that combines collaboration, games, challenges, healthy competition, and rewards can foster students' interest, self-confidence, and participation. The better the implementation of this learning model, the higher the learning motivation.

These findings are consistent with Setiana et al. (2025) regarding the relationship between TGT and learning motivation and Ratinho et al. (2026) regarding the relationship between gamification and motivation and engagement in mathematics learning.

4.3 Effect of students' learning ability on mathematics learning outcomes

Students' learning ability had a positive and significant effect on mathematics learning outcomes, with β = 0,594, t = 6,894, and p = 0,000. This coefficient represents the largest direct effect on mathematics learning outcomes in the model. These results indicate that the ability to understand concepts, process information, concentrate, think logically, solve problems, and apply mathematical knowledge is a major factor in achieving learning outcomes.

4.4 Effect of students' learning ability on learning motivation

Students' learning ability had a positive and significant effect on learning motivation, with β = 0,388, t = 3,913, and p = 0,000. Students who are able to understand the material well tend to have greater self-confidence, be more enthusiastic about participating in learning, and be more motivated to achieve academic success.

4.5 Effect of learning motivation on mathematics learning outcomes

Learning motivation had a positive and significant effect on mathematics learning outcomes, with β=0,528, t=4,705, and p=0,000. This coefficient indicates that motivation is an important factor in determining learning success. Students with high motivation tend to be more persistent, disciplined, active in asking questions, and persevering in completing tasks.

In the thesis, this relationship is explained as a psychological mechanism that directs learning behavior toward goal attainment. Ryan and Deci (2024), as cited in the thesis, explain the importance of motivation for engagement, persistence, and academic achievement.

4.6 The role of learning motivation as a mediator of the effect of the gamification-based Teams Games Tournament (TGT) cooperative learning model on learning outcomes

Learning motivation was shown to significantly mediate the effect of the gamification-based Teams Games Tournament (TGT) cooperative learning model on mathematics learning outcomes, with β indirect=0,260, t=3,537, and p=0,000. Because the direct effect of X1 on Y remained significant, the thesis interpreted the mediation pattern as partial mediation. This means that the gamification-based Teams Games Tournament (TGT) cooperative learning model affects learning outcomes through two pathways: a direct pathway and an indirect pathway through learning motivation.

4.7 The role of learning motivation as a mediator of the effect of students' learning ability on learning outcomes

Learning motivation also significantly mediates the effect of students' learning ability on mathematics learning outcomes, with β indirect=0,205, t=2,942, and p=0,003. These findings indicate that strong students' learning ability has a greater effect on learning outcomes when accompanied by high learning motivation. Motivation serves as a mechanism that strengthens the effect of students' learning ability on academic success.

Research implications

Theoretical Implications

Theoretically, this study reinforces the view that successful learning results from the interaction of external factors and students' internal factors. The gamification-based Teams Games Tournament (TGT) cooperative learning model was found to be associated with learning motivation and mathematics learning outcomes, whereas students' learning ability was also associated with both variables. Learning motivation was found to function as a mediating variable that explains part of the mechanism underlying the relationship between the learning model, students' learning ability, and mathematics learning outcomes.

This study also enriches research on gamification in elementary mathematics learning by integrating elements of games, challenges, rewards, and healthy competition into the Teams Games Tournament (TGT) model.

Practical Implications

For schools, the findings indicate the importance of encouraging teachers to implement innovative, interactive, student-centered learning. The gamification-based Teams Games Tournament (TGT) cooperative learning model can serve as an alternative approach to mathematics instruction. For teachers, learning can be designed through educational games, group work, rewards, challenges, and healthy competition. For students, the model is expected to enhance self-confidence, responsibility, collaboration, critical thinking skills, and motivation. For the Serang Regency Education Office, the findings may serve as a consideration in programs to improve teacher competence and develop learning communities.

STUDY LIMITATIONS

This study was conducted only among teachers at public elementary schools in Serang Regency; therefore, its findings cannot yet be broadly generalized to all elementary schools in Indonesia, including private schools or regions with different characteristics.

This study used a cross-sectional approach; therefore, the relationships among variables describe conditions only during the study period and do not explain long-term changes in motivation or learning outcomes.

Data were obtained through self-report questionnaires; therefore, the possibility of response bias, social desirability bias, and differences in respondents' diligence in providing answers remains.

One indicator in the gamification-based Teams Games Tournament (TGT) cooperative learning model construct had an outer loading of 0,591 and was retained because it remained above 0,50 and did not reduce the AVE or overall construct reliability.

The NFI value of 0,428 was below the ideal value of 0,90, although the SRMR value of 0,065 met the criteria used in the thesis.

The model included only the gamification-based Teams Games Tournament (TGT) cooperative learning model, students' learning ability, and learning motivation. Other factors, such as teacher competence, parental support, the learning environment, socioeconomic conditions, school facilities, prior ability, emotional intelligence, digital literacy, and other learning media, were not analyzed.

SEM-PLS is more oriented toward predicting relationships among variables than testing overall theoretical fit, as in CB-SEM.

Data collection conditions, such as intensive school activities, respondents' limited time, and variations in their understanding of questionnaire items, may have affected the quality of the responses.

Respondents had diverse employment statuses, including ASN and PPPK, but this study did not analyze differences in perceptions based on these statuses.

Time and cost limitations restricted the study to a number of public elementary schools and a specific study period.

5. CONCLUSION

This study indicates that all seven proposed hypotheses were accepted. First, the gamification-based Teams Games Tournament (TGT) cooperative learning model had a positive and significant effect on mathematics learning outcomes (β=0,307; t=3,854; p=0,000). Second, the gamification-based Teams Games Tournament (TGT) cooperative learning model had a positive and significant effect on learning motivation (β=0,493; t=5,402; p=0,000). Third, students' learning ability had a positive and significant effect on mathematics learning outcomes (β=0,594; t=6,894; p=0,000). Fourth, students' learning ability had a positive and significant effect on learning motivation (β=0,388; t=3,913; p=0,000). Fifth, learning motivation had a positive and significant effect on mathematics learning outcomes (β=0,528; t=4,705; p=0,000). Sixth, learning motivation significantly mediates the effect of the gamification-based Teams Games Tournament (TGT) cooperative learning model on mathematics learning outcomes (β=0,260; t=3,537; p=0,000). Seventh, learning motivation significantly mediates the effect of students' learning ability on mathematics learning outcomes (β=0,205; t=2,942; p=0,003).

The R^2 value of 0,638 for learning motivation indicates that 63,8% of its variance can be explained by the gamification-based Teams Games Tournament (TGT) cooperative learning model and students' learning ability, whereas the R^2 value of 0,781 indicates that 78,1% of the variance in mathematics learning outcomes can be explained by the variables in the model. Overall, this study underscores the importance of combining innovative learning strategies, students' learning ability, and learning motivation to support mathematics learning outcomes in the context of public elementary schools in Serang Regency.

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