Proceedings of International Conference on Islamic Education (ICIED)
Building an Inclusive and Sustainable Educational System
Volume 11, 2026 (p-ISSN 2477-3638 / e-ISSN 2613-9804)

Cooperative Learning, Technology Use, And Motivation In Mathematics Achievement: An Ordinal Logistic Regression Study

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Abstract
Mathematics learning in Indonesia faces challenges related to student achievement and mathematics anxiety. This study examines the role of pedagogical, technological, motivational, and Islamic educational values in supporting mathematics learning. The first study employed a quantitative survey design involving 100 students at SMA Negeri 1 Kedungpring, Lamongan, selected through stratified random sampling. Data were analyzed using ordinal logistic regression. The findings revealed that cooperative learning, technology use, and learning motivation simultaneously had a significant effect on mathematics achievement (Sig. = 0.002). However, only learning motivation had a significant partial effect (Sig. = 0.011). These findings highlight the importance of intrinsic motivation, supported by the Islamic values of ikhlas (sincerity) and ta'awun (mutual cooperation), in improving mathematics achievement. The second study developed Math Quest, an AI-integrated, web-based educational game incorporating the Islamic value of tawakkal (trust in God), to help mitigate mathematics anxiety. Using a Research and Development (R&D) approach based on the ADDIE model, the study involved expert validation, product implementation, and student evaluations. The results indicated positive expert assessments and student responses, with an average acceptance rate of 74.53%. Mathematics anxiety also decreased from 66.80% to 64.45%, representing a reduction of 2.35 percentage points. Overall, the findings suggest that effective mathematics learning requires a combination of appropriate pedagogical strategies, technological innovation, student motivation, and Islamic values. Integrating ta'awun, ikhlas, and tawakkal into mathematics education offers potential for improving academic achievement and creating a more supportive learning environment. Further research is needed to establish the effectiveness of these approaches through larger samples and more rigorous experimental designs.

Keywords:
Mobile Educational Game; Artificial Intelligence; Tawakkal; Mathematics Anxiety.

A. INTRODUCTION

In Islamic educational thought, the pursuit of knowledge ('ilm) is understood as both an intellectual and spiritual endeavor, where sound pedagogical methods and sincerity of intention (niyyah) are equally important for learning outcomes. Mathematics occupies a strategic position in the development o

f students' logical, analytical, and systematic thinking. Despite this, mathematics is widely considered one of the most challenging subjects at the senior high school level, a perception reflected

in persistently low national achievement. Data from the 2025 Academic Ability Test (TKA) indicate that the average national mathematics score ranges from only 36.10 for senior high school (SMA/SMK) and 37.03 for senior high school (SMA) on a 100-point scale, a result the Ministry of Primary and Secondary Education considers worrying and attributes to a weak numeracy culture and the need for fundamental improvements in mathematics pedagogy (Kemendikdasmen, 2025).

Findings from PISA 2022 reinforce this picture: Indonesian students continue to perform below the OECD average and particularly struggle to apply mathematical concepts to real-life contextual situations (OECD, 2023).

Previous studies have linked poor mathematics learning outcomes to shallow conceptual understanding and a lack of diverse teaching methods. Low levels of student engagement exacerbate these difficulties (Hiebert & Grouws, 2007; NCTM, 2014). At the same time, a growing body of research points to three factors that can significantly impact these learning outcomes: cooperative learning, the use of technology in instruction, and student motivation.

Cooperative learning places students in small, heterogeneous groups to pursue shared learning goals, resulting in social interactions that deepen understanding (Slavin, 1995). Its theoretical roots lie in Vygotsky's (1978) social constructivist explanation of the Zone of Proximal Development, where learners achieve higher levels of understanding through collaboration with more capable peers. Johnson and Johnson (1994, 2017) identified five essential elements of effective cooperative learning: positive interdependence, face-to-face promotive interaction, individual accountability, interpersonal and small-group skills, and group processing, which together ensure productive shared responsibility for learning. The empirical evidence is substantial: a meta-analysis of over 375 studies by Johnson et al. (2000) found that cooperative learning outperformed competitive and individualistic settings in achievement and interpersonal outcomes, while Zakaria et al. (2010) reported significantly higher post-test scores among Malaysian secondary school students taught with the cooperative STAD technique. Classroom studies in Indonesia present a more mixed picture: Rohendi et al. (2010) found that computer-assisted STAD increased motivation and achievement among high school students in Bandung, but the strength of the effect depended heavily on the accuracy of implementation.

The use of technology in teaching has also grown rapidly with increasing access to digital devices and the internet. Mayer's Cognitive Theory of Multimedia Learning (2014) explains that presenting material through a combination of visual and verbal channels can improve comprehension and retention. A meta-analysis of 46 controlled studies by Means et al. (2013) found that technology-assisted instruction outperformed conventional instruction with an average effect size of 0.24 standard deviations, and Hohenwarter and Jones (2007) showed that dynamic geometry software such as GeoGebra helps students build an intuitive understanding of mathematical relationships. In the Indonesian context, Yuanita et al. (2018) reported that students using GeoGebra in a high school in Surabaya outperformed a control group in geometry achievement. However, other studies caution that the benefits of technology depend more on the quality of implementation and teacher readiness than on access alone (Drijvers et al., 2010; Ertmer & Ottenbreit-Leftwich, 2010).

Learning motivation is a third factor of interest. Self-Determination Theory (Deci & Ryan, 2000; Ryan & Deci, 2000) distinguishes intrinsic motivation, which arises from the inherent satisfaction of learning, from extrinsic motivation, which depends on external rewards; this theory states that fulfilling learners' needs for autonomy, competence, and relatedness strengthens intrinsic motivation. Bandura (1997) further emphasized the central role of self-efficacy, and Pajares and Miller (1994) found that mathematics self-efficacy was a stronger predictor of performance than either math anxiety or prior experience. Longitudinal and cross-national evidence strengthens the link between motivation and achievement: Gottfried (1990) found that initial intrinsic motivation predicted later mathematics performance, and Areepattamannil et al. (2011) found a strong motivation–literacy relationship in PISA data even after controlling for socioeconomic background, and Wardani (2019) reported a significant positive correlation ($r = 0.61$, $p < 0.001$) between motivation and mathematics achievement among high school students in Malang.

These three constructs align closely with values long embedded in Islamic pedagogical thought. Cooperative learning is essentially a classroom expression of ta'awun 'ala al-birri wa al-taqwa (mutual cooperation in goodness and righteousness), as enjoined in Surah Al-Ma'idah [5]: 2.

In Islamic pedagogy, ta'awun is not only a social arrangement but also a spiritual obligation, where learners support each other in the pursuit of beneficial knowledge ('ilm nafi'). Recent Islamic education studies have explored this concept explicitly through several Qur'anic verses and their pedagogical implications for the classroom (Afandi, 2018). Similarly, intrinsically driven learning motivation reflects Islam's emphasis on ikhlas (sincerity)—acting sincerely for the sake of Allah—and sincerity of intention (niyyah) in one's endeavors. This aligns closely with self-determined intrinsic motivation as described by Deci and Ryan (2000): when students learn with sincere intentions and not for external rewards, their engagement and, potentially, their achievement can be expected to increase. When read together, these similarities suggest that the psychological constructs of Western motivation and Islamic educational values are not contradictory but complementary.

Although cooperative learning, technology use, and learning motivation have been studied extensively, research examining their simultaneous influence on mathematics achievement in Indonesian senior high schools, particularly using an ordinal logistic regression approach and grounded in Islamic pedagogical values, remains limited. This study addresses this gap by empirically examining the influence of cooperative learning, technology use, and learning motivation on students' mathematics achievement at SMA Negeri 1 Kedungpring, Lamongan.

The research questions that guide this study are: (1) Does cooperative learning affect students' mathematics achievement? (2) Does technology use affect students' mathematics achievement? (3) Does learning motivation affect students' mathematics achievement? (4) Do cooperative learning, technology use, and learning motivation simultaneously affect students' mathematics achievement? and (5) How do these findings inform an Islamic pedagogical approach to mathematics education? Thus, this study aims to analyze and describe the partial and simultaneous effects of these three variables on mathematics achievement, with the intention of providing practical guidance for mathematics teachers in designing effective and value-aligned instruction, and as a reference point for policymakers seeking to strengthen mathematics education at the senior high school level.

B. METHOD

This study used a quantitative approach with a survey research design, which is suitable for testing hypotheses about numerical relationships between variables (Creswell, 2014). A structured questionnaire was used to collect data from a representative sample of students.

The study population consisted of all 1244 students of SMA Negeri 1 Kedungpring, Lamongan, in grades X, XI, and XII. A sample of 100 students was selected through stratified random sampling, allocated proportionally across the three grade levels: 45 from grade X, 21 from grade XI, and 34 from grade XII to ensure representation across the school. Students were eligible for inclusion if they were actively enrolled during the 2025/2026 academic year and had complete and documented Midterm or End-of-Year Assessment scores for the respective semester.

The independent variables are cooperative learning (X1), technology use (X2), and learning motivation (X3), each measured by a five-item 0–5 Likert scale questionnaire. The dependent variable, mathematics achievement (Y), is taken from students' Mid-Semester Assessment scores (Grades X and XI) and End-of-Year Assessment scores (Grades XII), which were administered in March 2026, and categorized into five ordinal levels: 0 (Very Low: <20), 1 (Low: 21–40), 2 (Moderate: 41–60), 3 (High: 61–80), and 4 (Very High: 81–100).

The research instrument was validated by two validators to assess the suitability of the content to the indicators, the clarity of the language, and the accuracy of the measurement scale. The validated instrument consisted of 15 items: five for the Cooperative Learning Model (CLM), five for the Use of Technology (PT), and five for the Learning Motivation (MB). The assessment scale used was 1 to 4, with a score of 4 indicating very relevant or very clear and a score of 1 indicating irrelevant or unclear.

The assessment results from both validators showed that the instrument obtained an overall average score of 3.80 out of a maximum score of 4.00. Thus, the instrument's feasibility percentage reached 95.00%. Based on these results, the instrument is in the very suitable category for use. Reviewed by variables, the Cooperative Learning Model variable obtained an average score of 3.77 or 94.17%. The Technology Use variable obtained the highest average score, namely 3.90 or 97.50%.

Meanwhile, the Learning Motivation variable obtained an average score of 3.73 or 93.33%. These results indicate that all measured variables have statement items that are considered very appropriate, clear, and appropriate in the use of the measurement scale. However, the validator provided several technical and editorial correction notes. These corrections include the removal of remaining brackets in item MPK 2, correction of punctuation in item MPK 4, and correction of typos in the title of the section on Technology Use. In addition, there is a discrepancy between the assessment scale instructions that use a scale of 1–4 and the information in the general conclusion that still includes "5-point Likert". Therefore, the information needs to be corrected to "4-point Likert". Based on the assessment results and the validator's notes, it can be concluded that the research instrument has met the aspects of content feasibility, language clarity, and measurement scale accuracy. After improvements were made according to the validator's suggestions, the instrument was declared suitable for use in research data collection.

Data analysis was conducted in four stages: (1) validity testing using Pearson correlation, with items retained if the r-count exceeded the r-table value of 0.197; (2) reliability testing using Cronbach's Alpha, with a criterion of ≥ 0.70; (3) multicollinearity diagnostics based on Tolerance (> 0.10) and VIF (< 10); and (4) ordinal logistic regression. The ordinal logistic regression procedure consisted of a simultaneous significance test, a Goodness-of-Fit test, a partial Wald test, and the Nagelkerke R-Square coefficient of determination. Because ordinal logistic regression assumes proportional odds across response categories, the Parallel Lines assumption was tested before interpreting the model coefficients; a non-significant result ($p > 0.05$) supported this assumption and allowed one set of coefficients to be interpreted across all achievement categories. All analyses were conducted using the latest version of SPSS.

C. RESULTS AND DISCUSSION

Respondent Characteristics

Of the 100 respondents, 45 (45%) were 10th-grade students, 21 (21%) were 11th-grade students, and 34 (34%) were 12th-grade students. This distribution reflects the school's admissions policy, which allocates a larger number of study groups to the entry-level classes.

Validity and Reliability

Table 1. Summary of Instrument Validity Test Results

Variables	Goods	r count range	r table	Decision
Cooperative Learning (X1)	5	0.782 – 0.901	0.197	All valid
Use of Technology (X2)	5	0.748 – 0.855	0.197	All valid
Learning Motivation (X3)	5	0.847 – 0.879	0.197	All valid

All 15 instrument items in the three variables produced r-count values that were far above the r-table threshold of 0.197 (df = 98, α = 5%), which confirmed that each item was valid and appropriate for data collection.

Table 2. Results of Instrument Reliability Test

Variables	Cronbach's alpha	Number of items	Decision
Cooperative Learning (X1)	0.899	5	Reliable
Use of Technology (X2)	0.867	5	Reliable
Learning Motivation (X3)	0.915	5	Reliable

All three variables exceeded the 0.70 reliability criterion, with Learning Motivation demonstrating the highest internal consistency (α = 0.915), followed by Cooperative Learning (α = 0.899) and Technology Use (α = 0.867). Following George and Mallery's (2003) benchmark—where a value above 0.80 is categorized as "good" and a value above 0.90 as "very good"—all three instruments fall within the good to excellent range.

Multicollinearity Diagnosis

Table 3. Multicollinearity Test Results

Independent Variables	Tolerance	VIF	Comment
Cooperative Learning (X1)	0.323	3,098	There is no multicollinearity
Use of Technology (X2)	0.644	1,553	There is no multicollinearity
Learning Motivation (X3)	0.380	2,632	There is no multicollinearity

All Tolerance values exceeded 0.10 and all VIF values remained below 10, indicating the absence of problematic multicollinearity. Cooperative Learning showed the highest VIF (3.098), indicating moderate correlation with other predictors, but still within the acceptable range (Hair et al., 2014). This confirms that the obtained regression coefficients can be interpreted reliably.

Ordinal Logistic Regression: Model Fit and Assumptions

Table 4. Results of Model Fit and Assumption Tests

Test	Statistics	df	Significance
Simultaneous significance (Chi-Square)	15,257	3	0.002
Good Fit – Pearson	249,919	269	0.792
Model Fit – Deviation	211,384	269	0.996
Parallel Line Assumption	4,596	9	0.846

The simultaneous test yielded a Chi-Square of 15.257 with Sig. = 0.002, exceeding the critical Chi-Square value at df = 3 (7.815); therefore, the null hypothesis was rejected, indicating that cooperative learning, technology use, and learning motivation jointly and significantly influence students' mathematics achievement categories. This is consistent with Harini et al. (2022), who found that a combination of pedagogical and psychological factors jointly contribute to mathematics achievement. Both Goodness-of-Fit statistics (Pearson Sig. = 0.792; Deviance Sig. = 0.996) exceeded 0.05, indicating that the fitted model adequately represents the data. The Parallel Line Test was not significant (Sig. = 0.846 > 0.05), confirming that the proportional odds assumption holds for this dataset (Agresti, 2002; McCullagh, 1980) and supporting a valid interpretation of the model coefficients.

Partial Effects (Wald Test)

Table 5. Partial Results of the Wald Test

Variables	Estimating	Standard Error	Wald	Signature.	Exp(B)
Cooperative Learning (X1)	-0.088	0.101	0.755	0.385	0.916
Use of Technology (X2)	0.089	0.074	1,421	0.233	1,093
Learning Motivation (X3)*	0.222	0.087	6,420	0.011	1,249

**Significant at α = 0.05.*

Of the three predictors, only learning motivation significantly contributed to mathematics achievement (Wald = 6.420; Sig. = 0.011; $p < 0.05$). The Exp(B) value of 1.249 indicates that for every one-unit increase in motivation score, the probability of a student achieving a higher achievement category increases by approximately 24.9%, with other variables held constant. Cooperative learning (Sig. = 0.385) and technology use (Sig. = 0.233) did not reach significance individually. The Nagelkerke R-Square value of 0.149 indicates that the three predictors together explain only 14.9% of the variation in achievement categories, a relatively modest figure indicating that other unmeasured factors substantially shape students' mathematics outcomes.

Discussion

The finding that learning motivation was the only variable with a significant partial effect aligns with a large body of previous research. Schunk (2012) identified motivation as a consistent predictor of achievement across educational contexts, and both Wardani (2019) in Malang and Areepattamannil et al. (2011) using PISA data reported comparable significant relationships between mathematics motivation and achievement.

The insignificant partial effect of cooperative learning invites further examination. Previous studies such as Zakaria et al. (2010) and Johnson et al. (2000) reported a significant positive impact of cooperative learning on achievement. This difference may reflect several context-specific factors: variations in the fidelity of cooperative learning implementation in the classroom, heterogeneity of student abilities within the groups, prevailing school cultural norms regarding peer interaction at SMA Negeri 1 Kedungpring, and the specific cooperative learning structure used, all of which were not directly observed in this study. It is also worth noting that the instrument captured students' perceptions of cooperative learning rather than direct classroom observations of its implementation, which may underestimate the true impact of the construct.

From an Islamic education perspective, these findings point to practical rather than conceptual concerns. The value of mutual respect is affirmed in principle, but its realization in the classroom depends on how teachers intentionally structure positive interdependence and individual accountability (Johnson & Johnson, 1994, 2017; Afandi, 2018), not simply on students' overall impressions of the group activity. It stands to reason that group work without a clear structure of mutual respect (niyyah) and disciplined task allocation is tantamount to students simply sitting together rather than truly working together—the closeness of mutual respect (ta'awun 'ala al-birri wa al-taqwa). Future studies might benefit from examining whether the fidelity of cooperative learning, rather than its mere presence, explains differences in achievement, and designing group structures that explicitly foster mutual respect and accountability, with clear recommendations for teachers on how to strengthen the fidelity of implementation.

Similarly, the insignificant partial effect of technology use echoes the findings of Drijvers et al. (2010) and Ertmer and Ottenbreit-Leftwich (2010), who emphasized that the benefits of technology depend on the quality of implementation and teachers' competence in integrating it meaningfully, not just on students' perceptions of technology use. A concrete recommendation is: teachers should be trained not only to use technology, but also to integrate it meaningfully into mathematics tasks—choosing tools that support conceptual understanding rather than simply digitizing traditional exercises.

All three variables were simultaneously significant (Sig. = 0.002), suggesting a synergistic effect when cooperative learning, technology use, and motivation work together, consistent with Cobb et al.'s (2003) argument that the integration of multiple pedagogical factors yields a greater impact than any single factor alone. The moderate Nagelkerke R^2 (14.9%) indicates that approximately 85% of the variation in achievement categories remains unexplained by the three predictors examined here. Variables not captured in this model, such as students' prior mathematical knowledge, teacher quality, school facilities, socioeconomic status, and parental involvement, likely also shape achievement, and it is questionable whether the measurement instrument used here fully captures the intended constructs. For practical purposes, this moderate explanatory power suggests that teachers and policymakers should not view cooperative learning, technology use, and motivation as sufficient in isolation: they are necessary but not complete levers, best pursued in conjunction with ongoing attention to the quality of instruction and students' underlying knowledge.

Implications for Islamic Mathematics Education

Taken together, these findings suggest that motivation serves as the most direct lever for improvement, while cooperative learning and technology serve as important yet sensitive complements to implementation, echoing the Islamic pedagogical view that sincerity of intention (ikhlas, niyyah) and mutual cooperation (ta'awun) are mutually reinforcing and not stand-alone virtues in the pursuit of knowledge. Engagement with mathematics itself can be understood as no less important than the teaching method, as true learning (ta'allum) in the Islamic tradition is a form of worship ('ibadah) when undertaken with sincere intentions. Practically, this suggests that Islamic-

oriented mathematics pedagogy can intentionally cultivate niyyah before group assignments—for example, through concise frameworks linking the activity to shared benefits—and structure cooperative assignments around explicit accountability, rather than treating Islamic values as an implicit backdrop for other secular pedagogical methods.

D. CONCLUSION

Based on the results and discussion, four empirical conclusions can be drawn. First, cooperative learning, technology use, and learning motivation jointly and significantly influence the mathematics achievement category of students at SMA Negeri 1 Kedungpring, Lamongan (Chi-Square = 15.257; Sig. = 0.002). Second, only learning motivation has a significant partial effect (Sig. = 0.011; Exp(B) = 1.249), while cooperative learning (Sig. = 0.385) and technology use (Sig. = 0.233) do not. Third, the appropriate ordinal logistic regression model is adequate for the data (Pearson Sig. = 0.792; Deviance Sig. = 0.996) and meets the assumption of parallel lines (Sig. = 0.846). Fourth, the three predictors together only explained 14.9% of the variation in achievement categories (Nagelkerke R^2 = 0.149), indicating that other factors outside this model substantially shape students' mathematics learning outcomes.

These findings carry practical implications for mathematics teachers and, more broadly, for educators seeking to align pedagogy with Islamic values: maintaining students' intrinsic engagement and genuine motivation with mathematics appears to be the most direct lever for improving achievement, while cooperative learning and the use of technology remain valuable but require careful and faithful implementation—structured positive interdependence for cooperative learning, and purposeful pedagogical design for technology—to realize its full potential, in accordance with the values of ta'awun and ikhlas.

Future research is recommended to examine additional variables such as mathematics self-efficacy, teacher quality, and family support; combine self-report instruments with direct classroom observations for stronger ecological validity; and further explore faith-based cooperative learning models that explicitly operationalize ta'awun in mathematics classrooms, based on emerging works on Islamic-oriented cooperative learning.

ACKNOWLEDGMENTS

The authors would like to thank the principal, mathematics teachers, and students of SMA Negeri 1 Kedungpring, Lamongan, for their cooperation during data collection, and the Postgraduate School of Maulana Malik Ibrahim State Islamic University of Malang for its academic support during this research.

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