The Effect of Gerlach & Ely Instructional Design Model and Learning Motivation on Elementary Students' Mathematics Achievement

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Abstract: This study investigates the low mathematics achievement observed in elementary students taught using conventional instructional approaches. The research aims to examine the effect of the Gerlach & Ely instructional design model and students' learning motivation on mathematics achievement. A quasi-experimental method with a two-group design was applied, involving an experimental group receiving learning through the Gerlach & Ely model and a control group taught conventionally. Data were collected using a learning motivation questionnaire and a mathematics achievement test. Quantitative analysis, including comparison of mean scores and significance testing, was conducted to determine the effect of the instructional model and motivation levels. The findings show that students taught with the Gerlach & Ely model achieved significantly higher mathematics scores than those in the control group. High learning motivation also contributed positively to achievement, with motivated students outperforming those with lower motivation levels. Interaction analysis indicated that the Gerlach & Ely model remained effective across different motivation categories. The study concludes that structured instructional design has a substantial impact on improving mathematics performance and strengthening learning motivation. These results highlight the potential of adopting the Gerlach & Ely model more widely to enhance instructional quality in elementary mathematics education.

Keywords: Gerlach & Ely model; Instructional design; Learning motivation; Mathematics achievement

Introduction

Teaching mathematics has a prime position in the curriculum since it helps develop analytical reasoning abilities, systematic thinking, and structured problem-solving skills. It therefore serves as a cognitive backbone to other areas such as science, economics, and technology (Foster et al., 2021; Goos et al., 2020). Modern approaches to teaching mathematics increasingly incorporate interactive learning, digital tools, and interdisciplinary connections, which enhance student engagement, critical thinking, and the ability to apply mathematical knowledge in real-world scenarios (Kang, 2024). Unfortunately, continuous cases of underachievement in mathematics from elementary and middle school levels continue to be a growing concern in many parts of the world (Hidayat & Setyawan, 2020; Karim et al., 2024). Many have tried various methods of remediation with little impression on the performance level, understanding, and engagement of many learners, thus raising the need for more efficient instructional modes (Yulianto & Hidayanto, 2022).

Accordingly, the instructional design emerged as an appropriate solution in the segregation of teaching strategies aligned to student learning outcomes. Gerlach and Ely is among the most respected model in this arena. The model underpins the linkage of instructional objectives, characteristics of the learner, sequencing of content and resources, and continuous evaluation. By its systematic and adaptive components, this model permits educators to devise accurate and objective-oriented learning experiences (Amalia et al., 2023). It also assured that the instruction is directed by precisely defined ends, whilst still leaving room for tendency toward classroom dynamics. Pragmatic research reveals that such well-structured instructional models as Gerlach and Ely enhance the quality of mathematics teaching by providing a clear instructional road map. Particularly, Oktaviani et al. (2025) found the model to enhance effective time management, optimal delivery of materials, and ultimately, student comprehension in quantitative subjects. Similarly, Madsen (2020) showed that the model would enhance coherence of instruction and learner accountability, particularly in skill-based learning. Finally, Yusnita et al. (2016) mentioned that the model would establish clarity in the sequence of instruction, reduce ambiguities in the classroom, and encourage active participation in mathematics learning. Research conducted by Hossein-Mohand et al. (2023) has also shown that the amalgamation of model integrated instructional design with effective motivational strategies positively impacts students' performance in mathematics.

Aside from the truth of clarity of instruction, the one that one acknowledges as indispensable in the above discussion with regard to students' academic performance is motivation. Direction, intensity, and persistence result from the motivation factor. Findings that study by Al Fasha et al. (2023) are indicated to be an effect of good students' motivation in problems or obstacles since they show that the result is attributed to good students' motivation. Moreover, they also show that such students receive feedback better: they use it to change their behavior. The metamorphosed learning environment is such that motivates students emotionally, gives recognition to student participation, and supports autonomy in learning. Marniati et al. (2021) highlighted that the presence of social encouragement from teachers, parents, and peers reinforces learners' motivation to engage with complex academic tasks.

While instructional design and learning motivation may be individually significant factors for mathematics achievement, few studies have empirically considered their joint influence over achievement (Azizah et al., 2017). Most previous investigations had studied these factors in isolation, while ignoring the possibility of synergy between them during the promotion of cognitive and emotional readiness within learners. As stated by Tambunan et al. (2021), this fragmented research did not enable teachers to develop an integrated, responsive teaching strategy. Therefore, this necessitates an exploration of both variables simultaneously under a holistic instructional framework.

Evidence of immediacy in the predicament was also provided in the findings of classroom data recently. Assessment showing formative results from UPT SMPN 6 Koto XI Tarusan revealed that in the academic year 2024/2025, most students in both classes VIII.1 and VIII.2 failed to achieve the desired learning outcomes in the two mathematics assessments. These therefore do not just imply weaknesses in instructional methods but could also mean weaknesses in the motivational side of students.

Table 1. Formative Assessment 2 – Mathematics (2024/2025)

Class	Students	Highest Score	Lowest Score	Below Target (0–60)	Achieved Target (61–80)
VIII.1	21	79	40	16	5
VIII.2	21	75	25	15	6

Table 2. Formative Assessment 2 – Mathematics (2024/2025)

Class	Students	Highest Score	Lowest Score	Below Target (0–60)	Achieved Target (61–80)
VIII.1	21	77	30	16	5
VIII.2	21	80	35	15	5

Table 3. Initial Observation of Mathematics Learning Motivation

Motivation Indicator	Students	Percentage (%)
Perseverance in learning	6	30
Interest and attention to mathematics	8	40
Internal drive to understand the material	6	30
Goal-setting and aspiration	7	35
Pride in learning outcomes	8	40
Supportive environment (teacher, parents, and peers)	11	55

The conditions imply the requirement of a good instructional model with due consideration for motivation in its planning and implementation. According to the research by Kurniasari et al. (2023), the combination of clarity in instruction and motivational scaffolding tends to enhance learning performance, specifically in areas requiring mental abstractions like mathematics. Constructivist-based models, which emphasize active learning, problem-solving, collaboration, and scaffolding, have been shown to significantly improve metacognitive and problem-solving skills, as well as student motivation and engagement (Subba et al., 2025; Xie et al., 2018). Additionally, integrative frameworks that blend concrete-pictorial-abstract progression, task analysis, and supportive routines are effective for diverse learners, including those with learning disabilities, by personalizing instruction and fostering a supportive environment (Ingkavara & Yasri, 2025).

Thus, this present study is set to investigate the impact of the Gerlach and Ely Instructional Design Model and students' learning motivation on elementary students' mathematics achievement. Theoretically, it would contribute to the fields of instructional systems and motivational psychology. In practice, it is expected that the findings will provide educators with an evidence-based approach to designing mathematics instruction that is both pedagogically sound and affectively responsive.

Method

Research Design

This study employed a quasi-experimental approach with a Treatment by Block design. The primary factor consisted of the instructional model, comparing the Gerlach and Ely instructional design model (experimental group) with the conventional teaching model (control group). The blocking factor consisted of two motivation levels, namely high and low. These factors produced four subgroups: A1B1, A1B2, A2B1, and A2B2, where A1 denotes the experimental model, A2 the conventional model, B1 high motivation, and B2 low motivation.

Table 4. Research Design Treatment by Block

Teaching Model	Motivation Level	Group
Gerlach & Ely Instructional	High	A1B1
Design Model	Low	A1B2
Conventional Teaching Model	High	A2B1
	Low	A2B2

Notes: A1 = experimental group; A2 = control group; B1 = high motivation; B2 = low motivation.

Research Site and Duration

The research was conducted at SMPN 6 Koto XI Tarusan, located in Pesisir Selatan, West Sumatra. The implementation took place during the second semester of the 2024/2025 academic year under regular classroom conditions to preserve ecological validity.

Population and Sample

The population consisted of all eighth-grade students enrolled in the institution during the 2024/2025 academic year. Two intact classes, VIII.1 and VIII.2, each comprising 21 students, were selected through purposive sampling to represent students with comparable academic characteristics. Random assignment was then applied at the class level to determine the treatment conditions. Class VIII.1 was assigned as the experimental group and instructed using the Gerlach and Ely model, whereas Class VIII.2 functioned as the control group and received conventional instruction.

Type of Research

This investigation constituted a quantitative quasi-experimental study, characterized by the use of intact groups and differential instructional treatments without full individual randomization.

Research Procedure

The study followed several procedural steps. First, a motivation scale was administered to all students to classify them into high- and low-motivation categories. Second, both groups completed a diagnostic test to establish baseline equivalence. Third, treatment was implemented, with the experimental group taught through the Gerlach and Ely instructional design model and the control group taught through conventional methods. Fourth, a posttest consisting of essay-type items was administered to measure learning outcomes following the intervention. Finally, the collected data were organized for statistical analysis.

Research Instruments
Motivation Scale

A motivation scale consisting of 36 items was used to assess students' learning motivation. The instrument employed a five-point Likert format ranging from very positive to very negative responses. Items represented six motivational indicators and included both positive and negative statements.

Learning Outcome Test

The learning outcome assessment consisted of five essay questions aligned with the targeted learning objectives.

Table 5. Motivation Learning Indicators

Motivation Indicator	Positive Item Numbers	Negative Item Numbers
Persistence in learning	5; 16; 19; 36	14; 30
Interest and attention	11; 15; 21; 25	23; 31
Desire and needs	12; 18; 22; 28	6; 35
Hope and aspirations	7; 9; 13; 20; 26; 32	
Reward for achievements	1; 8; 10; 17; 27; 34	
Supportive environment	2; 20; 24; 29	3; 33

Table 6. Learning Outcome Assessment Test Specifications

Learning Objective	Test Indicator	Question Type	Question Number
Apply the Pythagorean Theorem to find the hypotenuse	Determine the hypotenuse of a triangle using the Pythagorean Theorem	Essay	1
Test the validity of right triangles	Verify the correctness of a triangle using the Pythagorean theorem	Essay	4
Solve problems involving Pythagorean triples	Identify Pythagorean triples	Essay	3
Apply triangle side ratios of 30°, 60°, 90°	Calculate the side lengths of a triangle based on 30° ratio	Essay	2
Relate real-world phenomena to right triangle models	Determine the height of an object from its shadow and distance	Essay	5

Validity and Reliability Testing
Validity Testing

Item validity for both the motivation scale and learning outcomes test was examined using Pearson's product-moment correlation coefficient. An item was classified as valid when its calculated correlation value exceeded the critical value in the r-table at the selected significance level. The formula used is:

$$rxy = \frac{N(\sum xy) - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}} \tag{1}$$

Reliability Testing

Reliability of the motivation scale was assessed using Cronbach's Alpha, expressed as:

$$r_{11} = \frac{K}{K-1}\left(1 - \frac{\sum Var(X_i)}{Var(X_T)}\right) \tag{2}$$

where K is the number of items, $Var(X_i)$ is the variance of each item, and $Var(X_T)$ is the total variance. The reliability analysis yielded an alpha coefficient of 0.810, indicating a high degree of internal consistency.

Validity of Learning Outcome Items

The validity test of the learning outcome questions was conducted using the calculated r value, which showed that all questions were valid. The results of the validity test are as follows:

Table 7. Results of the Validity Test

Question Number	r calculated	Remarks
1	0.794	Valid
2	0.806	Valid
3	0.95	Valid
4	0.803	Valid
5	0.898	Valid

Data Analysis

Data analysis was conducted to examine four hypotheses. Independent sample t-tests were used to compare mean learning outcomes across groups and subgroups. The hypotheses examined were as follows: (1) The difference in learning outcomes between the experimental and control groups. (2) The difference in learning outcomes between highly motivated students in the two groups. (3) The difference in learning outcomes between low-motivation students in the two groups. (4) The overall effectiveness of the Gerlach and Ely instructional model and the influence of motivation, derived through a deductive synthesis of the first three hypothesis tests.
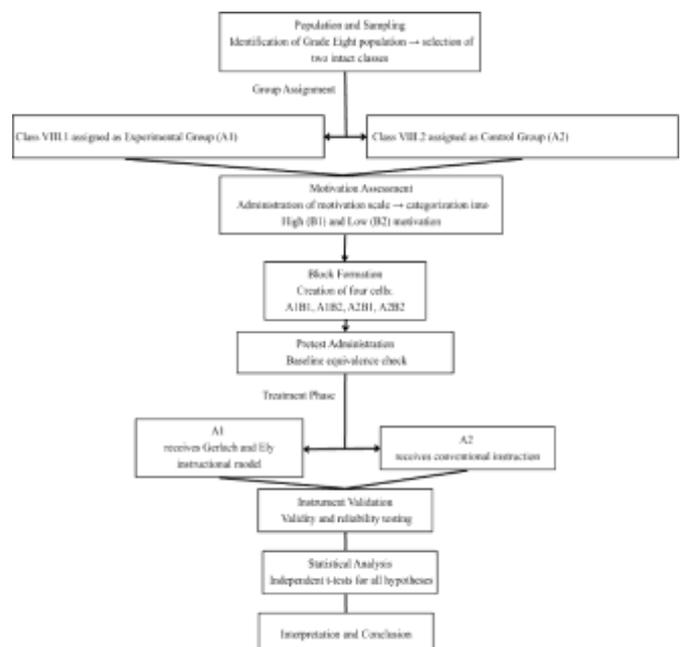

Figure 1. Research flowchart

The analysis determined whether the instructional model produced significantly higher mathematics learning outcomes and whether motivation functioned as a differentiating factor.

Result and Discussion

The current study has an objective effect on mathematics achievement among elementary school students through the Gerlach & Ely Instructional Design model along with the student learning motivation level. This research is conducted within the environment of SMPN 6 Koto XI Tarusan, engaging two eighth grades, namely VIII.1 and VIII.2, as respondents of 21 students in each class. The class is treated as the experimental group while using the Gerlach & Ely instructional model, while class VIII.2 is treated as a control group class, receiving classroom instruction through a conventional model of instruction. The intervention was conducted in five sessions, namely diagnostic test, three main instructional sessions, and a posttest with motivation questionnaire.

Descriptive Findings on Motivation and Achievement

Data collection was done through both a motivation questionnaire and a mathematics achievement test. According to Table 8, the average student learning motivation was high in the experimental group, which recorded an average of 93.10, while the control group reached merely an average of 55.76, classified moderate to low. Furthermore, the mathematics achievement results also favored the experimental group with the mean of 84.67 as compared to control group with 65.52.

Table 8. Descriptive Statistics of Learning Motivation and Mathematics Achievement in Experimental and Control Groups

Variable	Group	N	Mean	Median	Mode	Min	Max	Std. Dev.	Interpretation
Learning Motivation	Experimental	21	93.1	93	97	80	99	4.96	High
	Control	21	55.76	54	59	45	69	5.65	Moderate-to-Low
Mathematics Achievement	Experimental	21	84.67	85	85	60	98	10.28	Good–High
	Control	21	65.52	65	65	50	83	10.13	Fair

The data were analyzed for normality and homogeneity before their application for hypothesis testing. The samples were proved to be normally distributed and homogeneous by the Anderson-darling test, and the F-test as performed by Minitab ($p > 0.05$), hence the parametric analysis was carried out.

For testing the hypothesis, independent sample t-tests were applied. The first tested hypothesis questioned if there were any significant differences in mathematics achievement between students taught by the Gerlach & Ely model and those who learned through the conventional teaching method. The results gave a p-value of 0.000 indicating significant superiority of the Gerlach & Ely model. The second tested hypothesis dealt with the performance of students who were highly motivated to learn. Thus, a p-value of 0.000 confirmed that motivated students benefited more from the Gerlach & Ely model as compared with the conventional method. The third tested hypothesis considered students with low motivation, and again the p-value (0.024) showed that the experimental group was significantly favored. Therefore, the model is shown to be flexible and effective across motivational levels.

Combined Effects of Instructional Model and Motivation

The fourth hypothesis looked at the combined effect of the instructional model with motivation. Integrated so as to evaluate the different motivational groups, the inferential analysis confirmed that the Gerlach and Ely Model increases the mathematics achievement level for all motivational profiles. Students taught through this model showed more perseverance when tackling mathematical challenges as they received support through the structured and sequential phases of learning. The model promoted active engagement, attention, and deep learning in an environment created through properly designed instructional steps; students developed clearer academic goals, improved self-efficacy, and recognized their achievements owing to regular feedback. A nurturing learning environment sustained by meaningful interactions with both teachers and peers was another reinforcement to their motivation and achievements. Studies show that students taught with this model demonstrate improved mathematical communication skills, higher engagement, and better learning outcomes compared to those taught with conventional methods (Priyanda, 2020; Setiawati et al., 2018).

Instructional Strengths of the Gerlach and Ely Model in Teaching the Pythagorean Theorem

The Gerlach & Ely instructional design model in the study provided better learning outcomes compared to conventional teaching methods when applied for mathematics instruction, particularly for the topic of Pythagoras theorem. It provides a formally designed procedure so that every stage of instruction is clearly oriented to each student with respect to goal analysis,

content design, and evaluation. Yulia (2019) mentions that the systematic stages of this model allow instruction to be better organized and planned when teachers find it easier to adapt materials and methods; hence, this acts to improve students' understanding and learning outcome.

Additionally, learning motivation plays a vital role in increasing students' outcomes, particularly in mathematics, regarded as a difficult subject. Fitriani et al. (2023) assert that students with high motivation mostly produce better results because they actively participate in the learning process. However, the most interesting finding in the current study is that even low-motivated students significantly improved under the Gerlach & Ely model. Thus, the model is seen to cater to high-motivated students while on the other hand promoting an increase in intrinsic motivation among low-motivated students enabling them to perform better (Halidin & Ansar, 2020).

Contribution of Active and Media-Based Learning within the Gerlach and Ely Model

As one of the cardinal features of the Gerlach and Ely model, it encourages active learning, an indispensable tool for the effective comprehension of such complex topics as the Pythagorean theorem. Dini et al. (2025) emphasize the role instructional media must play in this endeavor, such as visualizing triangles or using concrete or digital tools to aid students in grasping abstract mathematics concepts. Concretes placed in the students' hands help not only to grasp tasks faster but also to grasp concepts better (Pramesti et al., 2025; Putri et al., 2025). Interactive digital tools, such as educational games and animated applications, significantly improve students' comprehension by visualizing geometric relationships and providing step-by-step proofs, making abstract ideas more accessible and engaging (Cahyanindya & Mampouw, 2020; Ihsan et al., 2025). An environment that is interactive and full of fun continues to sustain student interest and motivate them to remain active in the lesson.

Student Engagement and Interaction in Learning Activities

According to Schukajlow et al. (2023), students who are less motivated tend to feel detached in passive learning environments, such as lectures or one-way instruction. By providing diverse methods and media, the Gerlach and Ely model has sought to avoid some of these pitfalls by creating a much more heterogeneous and student-centered environment. Giving students some opportunity for interaction makes the activity more relevant to them, thereby motivating and engaging them, which eventually improves their learning outcomes (Arili et al., 2024).

Another key contributor to the success of the Gerlach and Ely model is the increased utilization of technology for learning, especially in teaching mathematics. As Irvy (2020) noted, when used in the right manner, technology creates an enjoyable learning experience for students as they interact with the content dynamically and engagingly. By digitally transmitting contents with the help of a calculator, or simulation of Pythagorean triangles, students are able to visually understand themselves the relationships between the sides of the triangle. Therefore, with technology integration, the experience is not only enriched but independent exploratory work by students is set in motion, leading to better insight into the subject.

The use of differential teaching strategies is another factor increasing the effectiveness of the Gerlach and Ely model. According to Surur (2022), the use of various strategies empowers students to respond to differing needs among learners thereby improving their understanding. The context in which one teaches the Pythagorean theorem is full of problems worked on by peers, making learning interactive. Such contrast causes students not to get bored, thus allowing them to digest the content.

Importance of Teacher Facilitation and Personalization in the Model

Choosing suitable instructional media is another important factor in helping students negotiate their understanding in complex undertakings like Pythagorean theorem. To Dini et al. (2025), in order to render abstract mathematics more tangible, visual media are of utmost importance. For the Pythagorean theorem, media including threes-dimensional models or computer applications showing the relation between triangle side lengths should allow students' more hands-on experiences with the concept. The visualization allows the students to then apply that theoretical knowledge back into practice thereby affirming their understanding (Mustafa et al., 2023; Shofiyyah & Qohar, 2022). Integrating a variety of visual and interactive instructional media helps students bridge the gap between theory and practice, affirming and reinforcing their understanding of the Pythagorean theorem (Lidya & Istikomah, 2021; Mtk et al., 2023).

In witnessing the responsiveness and individual nature of instruction, the teacher assumes an indispensable role. In Gerlach and Ely's perspective, the teacher is a facilitator who customizes learning experiences depending on the unique needs of students. The teacher, therefore, tailors methodologies and media differentially to meet students' varying requisites, guaranteeing complete comprehension of the material and improved learning outcomes among students with varying motivation attribution. This more personalized

approach therefore supports students' understanding of subject matter whilst also holding their interest and participation in the lesson.

Ultimately, challenge-based learning remains one of the best ways of aiding students in negotiating their understanding of deep mathematical concepts like the Pythagorean theorem. According to Jamil et al. (2024), challenges matching students' abilities are known to encourage critical thinking and problem-solving skills. With regard to teaching the concept of Pythagoras' theorem, the students are faced with challenges of practice that will involve applying the theorem as part of real-life events such as measuring distances and planning structures. Students are presented with real-world challenges, such as measuring distances or planning structures. They are encouraged to apply the theorem in practical contexts, which strengthens both their conceptual understanding and their critical thinking and problem-solving skills (Harihadi, 2024; Rewah et al., 2021). Indeed, this challenge-based learning not only strengthens the understanding of the theorem but also helps develop critical skills for real-world applications.

Overall Effectiveness of the Gerlach and Ely Model and Study Implications

The findings of the study suggest that the Gerlach & Ely instructional design model is one of the most effective designs for improving students' learning outcomes in mathematics, especially in teaching Pythagoras' theorem. This model has provision for various motivation levels among students while ensuring a structured and responsive approach to learning. Such results are in agreement with those of Ramli et al. (2023) and Safitri et al. (2024) conducting similar research, whereby the results show that the proper instructional design model leads to success in learning even for those students with low motivation. Thus, the teacher using this model can provide more engaging, interactive, and personalized learning experience which would improve the quality of education.

This study's major strength is using the Gerlach & Ely instructional design model, which is well structured and effective in improving mathematics learning outcomes, particularly on the Pythagoras theorem, as well as having-facilitating students with varying motivation levels. Compared to conventional teaching methods, this model leverages interactive media and clear instructional planning, resulting in better mathematical communication skills, increased student activity, and higher achievement. However, a limitation of the study is that it has a small sample size and lacks qualitative approaches that could provide deeper insights into other factors influencing learning

outcomes. On a practical note, this research offers positive implications for educators to apply the Gerlach & Ely model in creating more engaging and effective mathematics lessons, particularly on complex topics. Furthermore, this research can be an avenue for consideration in further advances within the instructional design in the field of mathematics education (Ramli et al., 2023).

Conclusion

The purpose of this study was to examine the effects of the Gerlach and Ely instructional design model and students' learning motivation on mathematics achievement in the topic of the Pythagorean theorem, and the findings indicate that the model substantially enhances students' learning outcomes across motivation levels by providing a structured, systematic, and media-supported framework that fosters more meaningful engagement than conventional instruction. The results also offer broader implications for instructional design in mathematics education, suggesting that organized instructional structures can reduce cognitive complexity and support both intrinsic and extrinsic motivational processes, making the model relevant for learners with diverse motivational profiles. Nevertheless, the study is limited by its small and homogeneous sample, which restricts generalizability, and by its reliance on quantitative measures that do not capture nuanced learning behaviors or classroom dynamics that may influence the model's effectiveness. Future investigations should therefore employ larger and more diverse samples and integrate mixed-method or qualitative approaches to examine more deeply how motivational factors interact with instructional design, while also exploring the applicability of the Gerlach and Ely model across different mathematical domains and educational levels to build a more comprehensive and contextually adaptable evidence base.

Author Contributions
All authors played a key role in preparing this manuscript. Each one made significant contributions to various aspects,

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