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The Relationship: Learning Motivation and Students' Mathematics Achievement on the Topic of Exponents

Raden Mohammad Luluk Herdiawan[1], Yatha Yuni[2]*, Ahmad Jauhari Hamid Ripki[3]
[1,2,3]Mathematics Education, STKIP Kusuma Negara, Indonesia
*yathayuni@stkipkusumanegara.ac.id

Abstract

This study aimed to empirically examine the relationship between learning motivation and students' mathematics achievement in the topic of exponents. A quantitative correlational research design was employed involving 29 Grade X students of SMK Negeri 11 Bekasi City, selected through cluster random sampling. Data were collected using a learning motivation questionnaire and a mathematics achievement test. Prior to hypothesis testing, a normality test using the Liliefors method confirmed that the regression residuals were normally distributed. Regression analysis yielded the equation $\hat{Y} = -17.575 + 1.169X$, indicating a positive relationship between learning motivation and mathematics achievement. The Pearson Product–Moment correlation analysis produced a correlation coefficient of $r = 0.881$, indicates a very strong positive correlation. Furthermore, the coefficient of determination (r^2) was 77.62%, indicating that learning motivation calculateded for 77.62% of the variance in students' mathematics achievement, while the remaining 22.38% was attributable to other factors. The significance test revealed that $t(27) = 9.676$, exceeding the critical value of 2.052. Therefore, learning motivation was found to have a significant positive relationship with students' mathematics achievement on the topic of exponent.

Keywords: learning motivation, mathematics achievement, exponents.

1 INTRODUCTION

Factors affecting learning outcomes can generally be divided into two broad categories: internal and external factors (Syafi'i, Marfiyanto, & Rodiyah, 2018). External factors encompass influences arising from the learner's environment, including teachers, peers, learning facilities, school climate, learning resources, and parents' socio-economic status (Dianti, F., 2023). Internal factors, on the other hand, consist of learner-related characteristics such as physical condition, intelligence, aptitude, interest, motivation, self-directedness, and attention level (Dianti, F., 2023). Although these factors are conceptually distinct, they are closely interconnected. In particular, students' internal motivation is often shaped by environmental influences, highlighting the dynamic interaction between internal and external factors in determining learning outcomes (Ilahude, Wantu, & Lukum, 2023).

Students with high learning motivation tend to be more active and engaged in learning activities and generally learn more effectively than those with lower levels of motivation (Lutfiwati, 2020). Strong learning motivation is often associated with higher academic achievement, as motivated students are more likely to persist in completing learning tasks and overcoming challenges (Suharni, 2021). Consequently, learning motivation is widely recognized as one of the key factors influencing learning outcomes. Students who possess higher levels of motivation are expected to achieve better academic performance. Therefore, fostering learning motivation is essential, as it encourages positive changes in students' learning behaviors and contributes to improved educational outcomes (Azhar & Wahyudi, 2024).

SMK Negeri 11 Bekasi City also faces challenges related to students' learning motivation. Based on field survey findings, students' mathematics achievement, particularly in the topic of exponents, remains below expectations. Analysis of mathematics test scores across several cohorts revealed that, on average, more than 50% of students failed to meet the Minimum Mastery Criterion (MMC) established by the school. In the 2024–2025 academic year, of the 36 tenth-grade students, 16 scored below the MMC, while only 20 students achieved or exceeded the required score of 75.

Interviews with students who did not meet the MMC indicated that low learning motivation was one of the primary contributing factors. Many students perceived mathematics as a difficult subject that requires extensive practice and assignments. They also reported that studying mathematics often causes fatigue and is sometimes perceived as monotonous and uninteresting. Consequently, students who fail to meet the MMC are required to participate in remedial programs or retake examinations to improve their scores.

Although remedial instruction and retesting are intended to help students achieve mastery, these measures may also impose additional academic pressure on students at SMK Negeri 11 Bekasi City. This situation highlights the importance of addressing students' learning motivation, particularly in mathematics, as a critical factor in improving academic achievement and reducing the need for repeated remedial interventions.

Every student aspires to achieve satisfactory learning outcomes in all subjects studied at school. Positive learning outcomes can help students attain their academic goals and support their overall educational development. Achieving such outcomes requires an effective and optimal learning process (Fernando, Andriani, & Syam, 2024). Without a well-structured and meaningful learning process, it is difficult for students to attain the expected level of achievement (Fatah, Suud, & Chaer, 2021).

Learning outcomes are also reflected in observable and measurable changes in students' behavior, particularly in terms of knowledge, attitudes, and skills (Cahyani & Winata, 2020). Following participation in the learning process, students are expected to achieve the intended learning objectives, which are manifested through their learning outcomes. According to Nana Sudjana, learning outcomes refer to the competencies and abilities acquired by students as a result of their learning experiences (Halimah & Adiyono, 2022). Therefore, learning outcomes can be understood as indicators of the extent to which students have successfully achieved the objectives of the educational process.

A motive refers to an internal drive within an individual or organization that creates a state of readiness to initiate a series of actions or behaviors (Rukiati, 2016). Motivation, on the other hand, is the process through which these motives are activated and translated into actions or behaviors aimed at fulfilling needs and achieving specific goals. Motivation can also be defined as a psychological condition and state of readiness that encourages individuals to engage in particular behaviors in pursuit of desired objectives.

According to Sarqawi *et al*. (2023), learning motivation is an internal drive that emerges and becomes active under certain circumstances. Learning itself is a mental and psychological process that occurs through active interaction with the environment, resulting in changes in knowledge, understanding, skills, and attitudes. Furthermore, learning motivation serves as a driving force that stimulates and encourages students to participate actively in the learning process (Annisa, 2019).

Therefore, learning motivation plays a crucial role in supporting students' engagement and persistence in learning activities, ultimately contributing to the achievement of better learning outcomes.

According to Clayton Alderfer, learning motivation is an internal drive that encourages students to engage in learning activities with the aim of achieving optimal academic success (Arief & Wiranugraha, 2020). Similarly, Koeswara defines motivation as an internal force that unconsciously activates, energizes, and directs an individual's behavior toward learning (Cahyono, Hamda, & Prahastiwi, 2022).

Based on these perspectives, motivation can be understood as a set of efforts aimed at creating conditions that encourage individuals to willingly engage in particular activities. When individuals experience reluctance or dislike toward an activity, motivation helps them overcome or minimize such negative feelings. In this context, a motive refers to the driving force that prompts an individual to take action, whereas motivation represents the state or process that activates and sustains that action.

Motivation and learning are two closely interconnected aspects that influence one another. Learning can be defined as a relatively permanent and potential change in behavior resulting from practice, experience, or reinforcement, leading to the achievement of specific outcomes. Motivation, meanwhile, serves as the driving force that directs individuals' behavior toward the attainment of those outcomes.

Therefore, it can be assumed that a relationship exists between learning motivation and mathematics learning outcomes. However, empirical investigation is needed to determine whether such a relationship is present and significant, particularly among students of SMK Negeri 11 Bekasi. Accordingly, this study aims to examine the relationship between learning motivation and mathematics learning outcomes among students at SMK Negeri 11 Bekasi..

2 RESEARCH METHODS

This study was conducted at SMK Negeri 11 Bekasi City, located in Bulak Macan Permai Residential Area, Jl. Mutiara Raya No. 81A, Harapan Jaya, North Bekasi, Bekasi City, West Java 17124, Indonesia. The research was carried out during the first semester of the 2024/2025 academic year.

The study employed a quantitative correlational research method, which focuses on examining the relationship between variables and determining the extent of the association between the independent and dependent variables. In this study, learning motivation served as the independent variable (X), while mathematics learning outcomes were designated as the dependent variable (Y). The research design is presented in Figure 1.

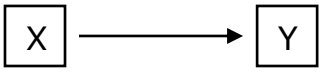

Figure 1. Correlation research design (Creswell, 2019)

Cluster sampling was employed as the sampling technique, following the procedure proposed by Sugiyono (2019). Two classes, namely Grade 10 Accounting Class C, and Grade 10 Accounting Class D. Calculateding, were randomly selected from the target population. Grade 10 Accounting Class C, consisting of 36 students, was assigned as the instrument-testing group, whereas Grade 10 Accounting Class D, consisting of 29 students, was designated as the research sample.

The instrument used to measure mathematics learning outcomes is a multiple-choice test on exponential material consisting of 30 questions. Each item provided five answer options (a, b, c, d, and e). A score of 1 was awarded for each correct answer, whereas an incorrect answer received a score of 0. The blueprint of the research instrument for the mathematics learning outcomes variable is presented in Table 1.

Table 1. Grid of the mathematics learning outcomes test instrument

No.	Learning Outcome Indicators	Questionnaire item
1	Classifying exponents	1, 2, 3, and 4
2	Implementing exponents	5, 6, 7, 8, 9, and 10
3	Classify Radical Expressions and Fractional Exponents.	15, 16, 17, 18, and 19

No.	Learning Outcome Indicators	Questionnaire item
4	Applying Radical Expressions and Fractional Exponents	11, 12, 13, 14, and 20
5	Classifying Logarithmic Expressions	21 & 24
6	Applying Logarithmic Concepts	22, 23, 25, 26, 27, 28, 29, and 30

The 30 test items initially developed, the instrument pilot test results indicated that 22 items were valid. The reliability coefficient of the mathematics learning outcomes instrument was 0.887, which falls into the very high reliability category (Purwanto, 2018). Similarly, for the learning motivation questionnaire, 22 out of the 30 statement items were found to be valid, with a reliability coefficient of 0.859, also classified as very high reliability.

These findings demonstrate that both the mathematics learning outcomes instrument (dependent variable, Y) and the learning motivation instrument (independent variable, X) exhibit adequate levels of validity and reliability. This indicates that the instruments are capable of accurately measuring the intended constructs and producing consistent results, thereby making them suitable for use in the present study. Establishing the validity and reliability of the research instruments is essential to ensure the accuracy and credibility of the data collected. Following the instrument validation process, prerequisite analyses were conducted to assess whether the data met the assumptions required for subsequent statistical procedures. These analyses included tests of normality and linearity. The normality test was performed to determine whether the data were normally distributed, while the linearity test was conducted to examine the nature of the relationship between learning motivation and mathematics learning outcomes. The results of these prerequisite tests served as the basis for selecting the appropriate statistical techniques and ensuring the validity of the hypothesis-testing process.

3 RESULT AND DISCUSSION

Data on the learning motivation variable were collected using a questionnaire, while data on mathematics learning outcomes were obtained through a multiple-choice achievement test. Both instruments had previously undergone validity and reliability testing and were found to meet the required psychometric standards for research purposes.

The study involved a sample of 29 students from Grade 10 Accounting Class D at SMK Negeri 11 Bekasi City. The learning motivation questionnaire was administered to assess students' levels of motivation toward learning mathematics, whereas the mathematics achievement test was used to measure students' mastery of the learning material. The descriptive statistics of both variables, including measures of central tendency and data distribution, are presented and discussed in the following section.

3.1 Description of Learning Motivation

The learning motivation data of 29 students from Grade 10 Accounting Class D at SMK Negeri 11 Kota Bekasi, the results presented in Table 2.

Table 2. Frequency Distribution of Motivation to Learn Variable (X)

Class intervals	Midpoint (Xi)	motivation to learn	
		Frequency (F)	Real class boundaries
59 - 65	62	5	58.5 – 65.5
66 - 72	69	5	65.5 -72.5
73 - 79	76	5	72.5 – 79.5

Class intervals	Midpoint (Xi)	motivation to learn	
		Frequency (F)	Real class boundaries
80 - 86	83	5	79.5 – 86.5
87 - 93	90	6	86.5 – 93.5
94 - 100	97	3	93.5 – 100.5

Based on the data presented in Table 2, the highest score was 95 and the lowest score was 59. Statistical calculations revealed a mean of 78.655, a median of 78.8, a mode of 88.25, a variance of 134.448, and a standard deviation of 11.595. The distribution of the data is illustrated in the following Figure 2:

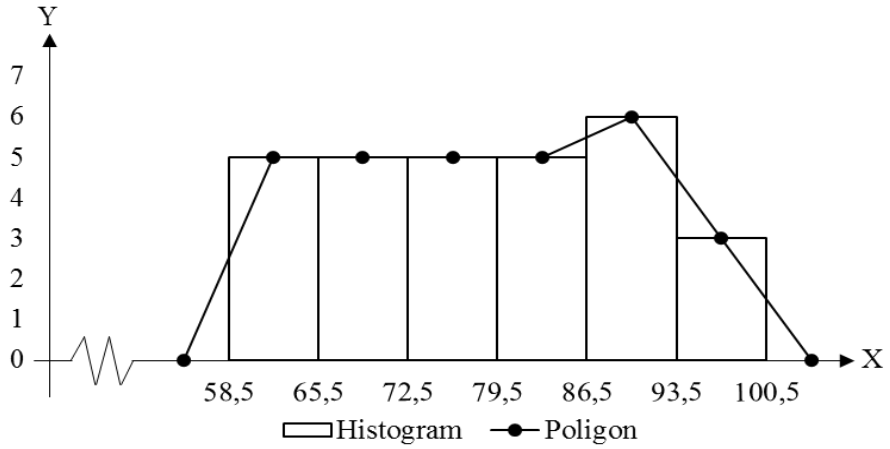

Figure 2. Histogram and Frequency Polygon of Students' Learning Motivation

3.2 Description of Mathematics Learning Achievement

Data on students' mathematics learning outcomes were obtained through a standardized objective test comprising multiple-choice questions on exponent material. Before being administered to the participants, the instrument underwent rigorous validity and reliability testing. Item validity was evaluated using the point-biserial correlation method, whereas reliability was determined using the Kuder–Richardson Formula 20 (KR-20). The analysis confirmed that the instrument possessed satisfactory psychometric properties and was therefore suitable for assessing students' mathematics achievement.

The participants consisted of 29 students from Grade 10 Accounting Class D at SMK Negeri 11 Kota Bekasi. Following the administration of the test, students' responses were scored and subjected to descriptive statistical analysis. The resulting data, which provide an overview of students' mathematics learning outcomes on exponent concepts, are presented in Table 3.

Table 3. Frequency Distribution of Mathematics Learning Achievement (Y)

Class intervals	Midpoint (Yi)	Mathematics Learning Achievement	
		Frequency (F)	Real class boundaries
23 - 35	29	1	22.5 – 35.5
36 - 48	42	1	35.5 -48.5
49 - 61	55	2	48.5 – 61.5
62 - 74	68	9	61.5 – 74.5
75 - 87	81	15	74.5 – 87.5
88 - 100	94	1	87.5 – 100.5

Based on the results of the multiple-choice test on the exponent topic presented in Table 3, the highest score obtained was 95, while the lowest score was 23. Using a frequency distribution table, the statistical analysis revealed a mean score of 72.482, a median of 75.8, a mode of 78.4, a variance of 184.401, and a standard deviation of 13.579. The detailed calculation process is provided in the Appendix section.

To facilitate a clearer understanding and interpretation of the research data, the score distribution is presented graphically through a histogram and frequency polygon, as shown in Figure 3. These graphical representations provide a visual overview of the distribution pattern of students' mathematics learning outcomes on the exponent material.

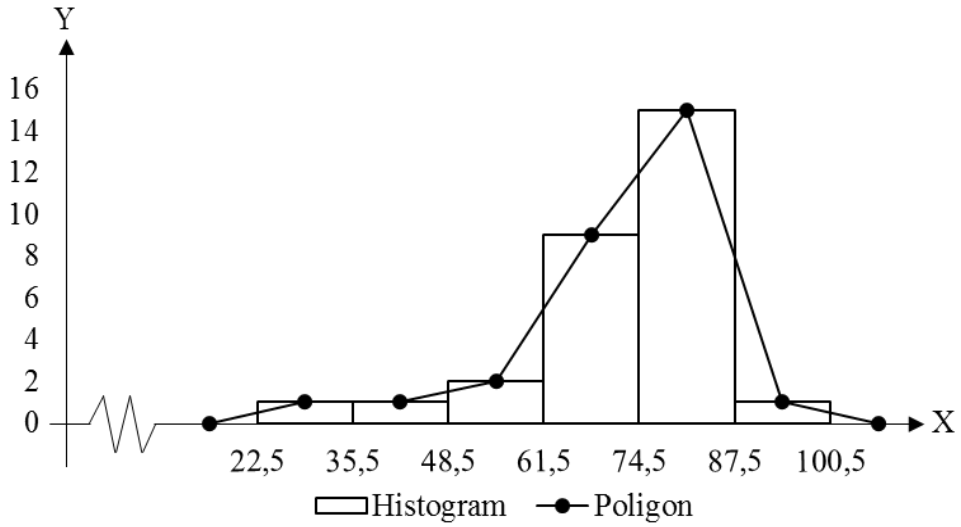

Figure 3. Histogram and Frequency Polygon of Mathematics Learning Achievement

3.3 Prerequisite Tests for Data Analysis

Prior to hypothesis testing, prerequisite tests for data analysis must be conducted. These tests are intended to determine the appropriate statistical procedures for testing the research hypothesis. The prerequisite analysis begins with a normality test to examine whether the learning motivation data and mathematics learning outcomes data on the exponent topic are normally distributed. Once the data are confirmed to be normally distributed, a linearity test is performed to determine the degree of linear relationship between the independent variable (X) and the dependent variable (Y).

3.3.1 Normality Test

Based on the learning motivation questionnaire scores and mathematics achievement scores on the topic of exponents obtained from 29 participants, a normality test was conducted using the Liliefors test. The procedure was carried out through the following steps:

a. For the learning motivation data (Variable X), the mean score was 78.655 and the standard deviation was 11.595. These values were used to calculate the standardized score (Zi) using the following formula $= \frac{X_1 - \bar{X}}{s}$. Subsequently, the value of F(Zi) was determined by referring to the standard normal distribution table (the area under the normal curve). The value of S(Zi) was then calculated by dividing the cumulative frequency of each score by the total number of observations (n = 29). Based on these calculations, the following values were obtained: $|F(Zi) - S(Zi)|$. The largest absolute difference obtained was taken as the $L_{calculated}$ = 0,1312, where as the critical Liliefors value for a sample size of 29 at the 0.05 significance level was 0.1645. Because $L_{calculated}$ (0.1312) was lower than L_{table} (0.1645), the null hypothesis

of normality was accepted, indicating that the data for the learning motivation variable (X) were normally distributed.

b. Mathematics achievement in the topic of exponents (Variable Y) yielded a mean score of 72.482 and a standard deviation of 13.579. The standardized scores (Zi), cumulative probabilities (F(Zi)), and empirical cumulative frequencies (S(Zi)) were computed following the same procedure used for the learning motivation variable (X). The largest absolute difference, |F(Zi) − S(Zi)|, was used as the $L_{calculated}$ = 0,1252, where as the critical Liliefors value for a sample size of 29 at the 5% significance level was 0.1645. Because $L_{calculated}$ (0.1252) was lower than L_{table} (0.1645), the null hypothesis of normality was accepted, indicating that the mathematics achievement data (Variable Y) were normally distributed. The complete results of the normality analysis are presented in the following Table 4.

Table 4. The Normality Test Results for Variables X and Y

Variable	Sample Size (n)	$L_{calculated}$	L_{table}	Conclusion
Learning Motivation	29	0,1312	0,1645	Normally Distributed
mathematics achievement	29	0,1252	0,1645	Normally Distributed

3.3.2 Linearity Test

The linearity test was conducted as a prerequisite for inferential analysis in assessing the association between variables. This test aimed to determine whether the relationship between the variables was linear by testing the following hypotheses: $H_0 : \hat{Y} = a + bx$ (linear) and $H_1 : \hat{Y} \neq a + bx$ (non linear). The linearity of the data was assessed using the calculated F-statistic for both the significance and linearity tests. The F calculated value was obtained from the ratio of the regression mean square to the error mean square ($RJK_{rc}/RJK_{eror)}$, as shown in Table 5.

Table 5. The Linearity Test

Source of Variation	df	Sum of Squares (SS)	Mean Square (MS)	$F_{calculated}$	F_{tabel}
Total (T)	29	164624			
Regression (a)	1	157917,241	157917,241		
Regression (b)	1	5210,031	5210,031		
Residual	27	1496,728	55,434	0,402	3,864
Lack of Fit (Tuna cocok)	21	875,562	41,693		
Pure error (Galat)	6	621,166	103,527		

As shown in Table 4, the linearity test yielded $F_{calculated}$ = 0.402, which was lower than F_{table} = 3.864 at the 0.05 significance level. Because $F_{calculated} < F_{table}$, the null hypothesis was accepted, indicating a linear relationship between learning motivation and mathematics achievement.

3.4 Hypothesis Testing

To examine the strength of the relationship between Variable X and Variable Y, correlation analysis was employed. Specifically, the Pearson Product–Moment correlation coefficient was used because both variables met the prerequisite assumptions of normality and linearity. The detailed results of the analysis are presented below:

3.4.1 Pearson Product–Moment Correlation Analysis

The Pearson Product–Moment correlation analysis is a parametric statistical technique that requires interval or ratio data and several underlying assumptions. Specifically, the data must be randomly selected, normally distributed, and exhibit a linear relationship between paired observations.

To determine the strength of the relationship between learning motivation and mathematics achievement on the topic of exponents, the correlation coefficient was calculated using the Pearson Product–Moment correlation formula. The analysis yielded a correlation coefficient of r = 0.881. This value was then compared with the critical value from the correlation table at a significance level of 0.05 and a sample size of 29, resulting in r table = 0.367. Since r calculated = 0.881, the alternative hypothesis (H_1) was accepted. This result indicates a significant relationship between learning motivation and mathematics achievement on the topic of exponents.

These findings are consistent with those reported by Kurniasari, Yarmi, and Kartono (2023), who likewise found that learning motivation plays an important role in improving students' academic achievement.

3.4.2 Correlation Significance Test

To assess the significance of the correlation coefficient (r = 0.881), a t-test was performed. The results indicated that t calculated = 9.676, which exceeded the critical value of t table = 2.052 at the 0.05 significance level. Therefore, the null hypothesis was rejected, indicating that learning motivation has a statistically significant contribution to students' mathematics achievement on the topic of exponents.

3.4.3 Coefficient of Determination Calculation

The coefficient of determination (r^2) was calculated by squaring the correlation coefficient and multiplying it by 100%. With a correlation coefficient of r = 0.881, the resulting r^2 value was 77.62%, indicating that learning motivation explained 77.62% of the variance in mathematics achievement, while the remaining 22.38% was influenced by other factors.

4 CONCLUSION

Mathematics achievement among vocational high school students in Bekasi, particularly at SMK Negeri 11 Bekasi City, has generally remained at a relatively low level, one of the contributing factors being students' low motivation to learn mathematics. The findings of this study demonstrate that learning motivation has a significant influence on mathematics achievement, calculateding for nearly 77,62% of the observed variance. This result indicates that lower levels of learning motivation tend to be associated with lower mathematics achievement. Conversely, students with higher learning motivation tend to achieve better learning outcomes. This tendency is further supported by the linearity analysis, which revealed a positive directional relationship between the two variables. Therefore, learning motivation can be considered one of the dominant factors influencing students' success in understanding mathematical concepts, particularly the topic of exponents.

Based on the findings, it can be concluded that there is a strong relationship between learning motivation and mathematics achievement on the topic of exponents among Grade 10 students at SMK Negeri 11 Bekasi City. These findings highlight the importance

of enhancing students' learning motivation through more varied, engaging, and student-centered instructional strategies that are aligned with the characteristics and learning needs of vocational high school students.

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