

# Analysis of the Effect of Social Circles on the Grade Point Average of Mathematics Students in the Class Of 2025 Using a Graph Theory Approach

Alfian Putra Ardana<sup>1</sup>, Rodiyatul Adawiyah<sup>1</sup>, I Gede Adhitya Wisnu Wardhana<sup>1\*</sup>,  
Rohaidah Masri<sup>2</sup>, Maris Tabalon Lasco<sup>3</sup>, Deni Hamdani<sup>4</sup>

<sup>1</sup>Department of Mathematics, Universitas Mataram, Indonesia

<sup>2</sup>Department of Mathematics, Universiti Pendidikan Sultan Idris, Malaysia

<sup>3</sup>Department of Mathematics Education, College of Education Graduate Studies Caraga State  
University, Philippines

<sup>4</sup>Department of Mathematics Education, Universitas Mataram, Indonesia

[adhitya.wardhana@unram.ac.id](mailto:adhitya.wardhana@unram.ac.id)

## ABSTRACT

### Article History:

Received : 02-07-2026

Revised : 29-07-2026

Accepted : 14-09-2026

Online : 23-10-2026

### Keywords:

Graph Theory;

Node Degree;

Friendship;

GPA;

Linear Regression.



Student academic achievement, as measured by Grade Point Average (GPA), is influenced by various factors, including the social environment. This study aims to analyze the relationship between friendship networks and students' GPA using a graph theory approach, offering an alternative perspective to conventional perception-based analyses of peer influence. The study involved 93 students from the Mathematics Study Program at the University of Mataram. Friendship data were collected through a structured sociometric questionnaire administered via Google Forms, while GPA data were obtained from the official academic records of the study program with formal authorization. Students were represented as vertices and friendship relationships as weighted edges based on the level of closeness. The friendship network was analyzed using graph theory, and the relationship between node degree and GPA was examined through simple linear regression. The results revealed a weak and statistically insignificant relationship between friendship networks and students' GPA. These findings suggest that the structural characteristics of friendship networks alone are insufficient to explain academic performance, which is likely influenced by multiple academic and social factors. This study demonstrates the potential of graph theory as an alternative approach for modeling friendship networks and provides a foundation for future research incorporating more comprehensive network metrics and additional explanatory variables.



<https://doi.org/10.31764/jtam.v10i4.40648>



This is an open access article under the **CC-BY-SA** license

## A. INTRODUCTION

Education is one of the key aspects in enhancing human resource quality and serves as the primary means of developing an individual's intellectual abilities, skills, and character (Tyas et al., 2020). Through education, individuals not only acquire academic knowledge but also develop critical thinking, communication, collaboration, and problem-solving skills to address challenges in daily life (Dilekçi & Karatay, 2023). In the context of higher education, students are expected to develop both their academic and social potential so they can adapt to the rapid advancements in science and technology (Aithal et al., 2024).

Student success in the educational process is generally measured through the cumulative grade point average (CGPA), which reflects the level of academic achievement during their studies (Kumar et al., 2021). The level of a student's GPA is influenced not only by intellectual ability but also by various other factors, one of which is the social environment (Suryawan & Putra, 2016). The social environment in higher education is formed through interactions among students, whether in learning activities, discussions, organizations, or daily activities on campus (Sá, 2023).

In college life, students tend to build social relationships in the form of friendships with other students (McCabe, 2019). These friendships indirectly shape students' social status on campus (Read et al., 2020). Students with extensive social networks tend to more easily access academic information, form study groups, exchange knowledge, and receive emotional support and motivation throughout the learning process (Eid & Al-Jabri, 2016). Conversely, students with poor social relationships may face obstacles in their academic journey due to a lack of interaction and support from their surroundings (Pavin Ivanec, 2022).

Peer relationships among students have the potential to influence students' academic achievement (Schmidt, 2020). A positive peer environment that supports the learning process can enhance motivation, enthusiasm for learning, and students' ability to understand course material (Dalimunthe et al., 2024). Therefore, students' social relationships are an interesting factor to analyze in relation to their GPA achievement, particularly among mathematics students, whose learning is characterized by analysis, discussion, and problem-solving (Zhou et al., 2020).

Numerous studies have investigated the relationship between friendship and students' Cumulative Grade Point Average (CGPA) using various statistical approaches. One such study was conducted by Utami et al. (2025), who examined the influence of social factors, including friendship, on students' academic performance using multiple linear regression. This approach is capable of identifying the statistical influence of each social factor on students' CGPA based on relationships among variables. However, multiple linear regression treats friendship as an independent variable and therefore cannot adequately represent the structure of friendship networks or capture each student's level of connectedness within the social network. Therefore, an alternative approach is required to explicitly model interpersonal relationships as a network.

One mathematical approach that can be used to model students' social relationships is graph theory (Safetra et al., 2026). Graph theory is a branch of mathematics that studies relationships between objects through the representation of vertices and edges (Zhao, 2023). Graph theory has been widely applied to various fields. In operations research, it is used to find optimal routes for goods distribution (Ardhyani, 2017). In chemistry, it is used to predict the physical properties of chemical compounds by modelling molecular structures into graph form (Ardana et al., 2025). These successful applications demonstrate that graph theory also has strong potential for modelling friendship networks among students. In this study, each student is represented as a node, while the friendships between students are represented as edges (Nadeak, 2025). By using a graph model, patterns of students' social relationships can be analyzed systematically and mathematically. One important concept in graph theory is the degree of a node, which refers to the number of edges connected to a node (Asmarani et al.,

2022). Therefore, the degree of a node represents the number of friendship relationships possessed by each student and serves as an indicator of students' social connectedness. Subsequently, the relationship between students' node degree and their cumulative grade point average is examined.

Based on the above, this study was conducted to analyze the influence of friendship relationships on the cumulative grade point average of mathematics students using a graph theory approach. This study is expected to provide insights into the relationship between students' social status, represented in the form of a graph, and their academic achievement. Additionally, the research findings are expected to contribute to understanding the importance of a supportive social environment for students' learning processes in higher education.

## B. METHODS

This study is quantitative in nature. Its objective is to analyze the influence of friendships among mathematics students on their Grade Point Average (GPA) through a graphical representation of their social networks. This study involved 93 mathematics students from the same cohort who were interviewed directly via Google Forms. The following are the steps taken in this study.

1. The first stage of this study involved collecting data on students' friendships and their GPAs. Friendship data were collected using a structured sociometric questionnaire administered through Google Forms. Respondents first provided their names for identification purposes and were subsequently asked to identify their classmates based on four categories of social relationships: not friends, casual friend, close friends, and best friends. These responses were used to construct the friendship network, in which each student was represented as a vertex and each reported friendship relationship as an edge. GPA data were obtained from the official academic records of the Mathematics Study Program after formal authorization had been granted by the program administration. In this study, each student is represented as a vertex labeled using their Student Identification Number (NIM). Relationships between students are represented as edges with weights corresponding to the level of friendship closeness, namely (Hall, 2019):
  - a. Not friends: no edge,
  - b. Casual friend: has 1 edge,
  - c. Close friend: has 2 edges,
  - d. Best friend: has 3 edges.

The number of edges was determined based on the assumption that stronger friendship relationships represent more frequent interactions and stronger social influence than weaker friendships. Therefore, casual friends were represented by one edge, close friends by two edges, and best friends by three edges. This representation enables the vertex degree to reflect not only the number of friendship relationships but also their relative intensity. In addition to friendship relationship data, each student's GPA was also collected as an academic variable to be analyzed.

2. The friendship relationship data obtained was then modeled into a simple graph. Suppose the graph is represented as  $G = (V, E)$  where (Ghebleh et al., 2026):
  - a.  $V$  is the set of vertices representing students.
  - b.  $E$  is the set of edges representing friendship relationships among students.

Each node in the graph is labeled according to the student's ID number. The edge weight indicates the level of social closeness between students. Next, the degree of each vertex is calculated. The degree of a vertex indicates the number of connections a student has with other students in the friendship network.

3. The final step is to analyze the relationship between the degree of each node and the student's GPA using regression analysis. In this study, node degree is used as the independent variable, while the student's GPA is used as the dependent variable. The simple linear regression model used can be written as (Kurniawan, 2016):

$$Y = a + bX \quad (1)$$

Where:

$Y$  = Student GPA

$X$  = student node degree

$a$  = constant

$b$  = regression coefficient

The results of the analysis were then interpreted to draw conclusions regarding the influence of friendship social networks on students' Grade Point Average (GPA). For a clearer understanding of the research methodology, the overall research process is presented in Figure 1 below.

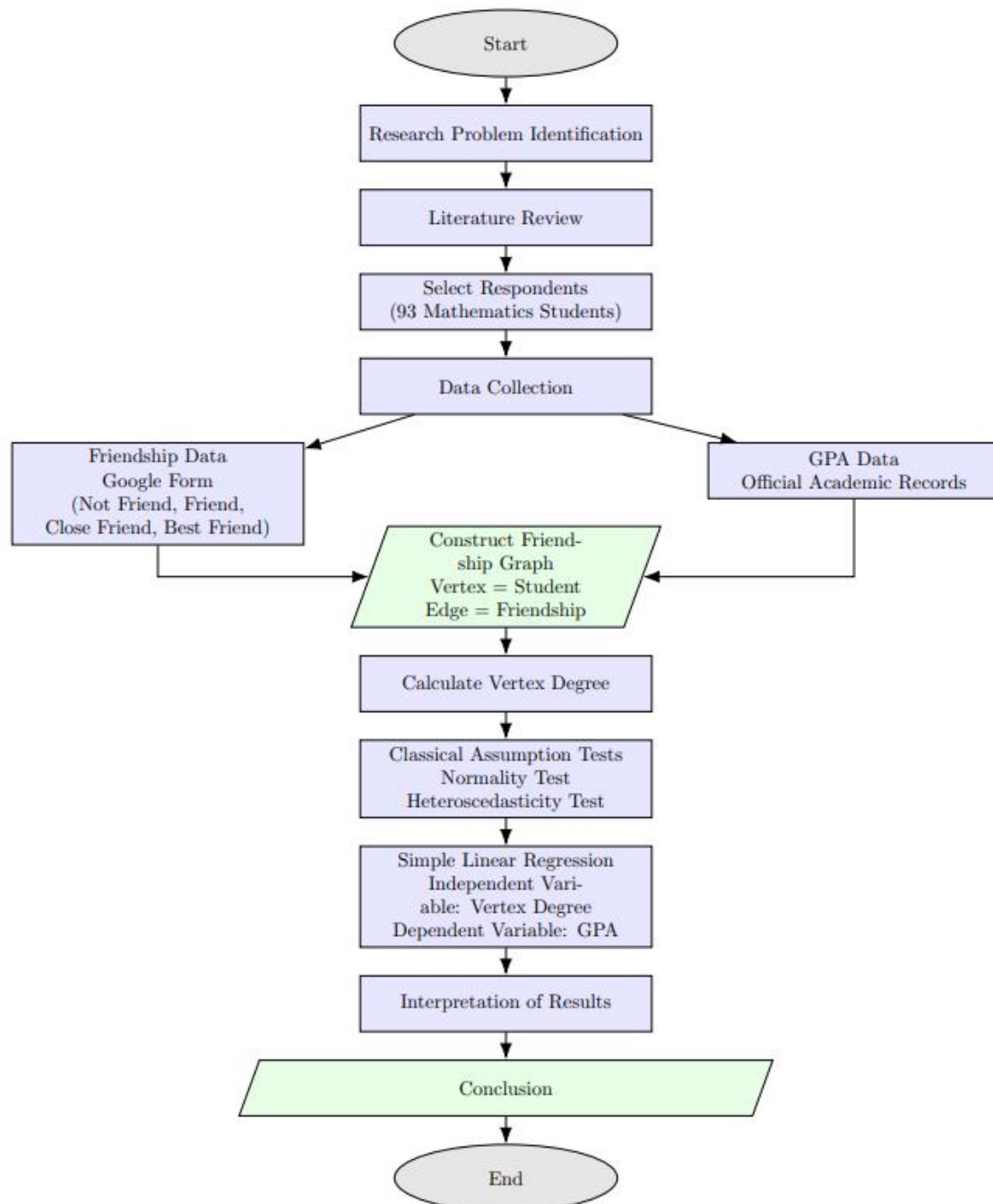


**Figure 1.** Research Flowchart

### C. RESULT AND DISCUSSION

This study aims to analyze the relationship between student friendships and the cumulative grade point average (GPA) using a graph theory approach, based on the degree of each node representing each student. Therefore, this study will collect all friendship data from each student, specifically within the Mathematics Study Program, Faculty of Mathematics and Natural Sciences, Mataram University, which will then be modelled as a graph. The following is a graphical representation of the friendship relationships among the students, as shown in Figure 2.

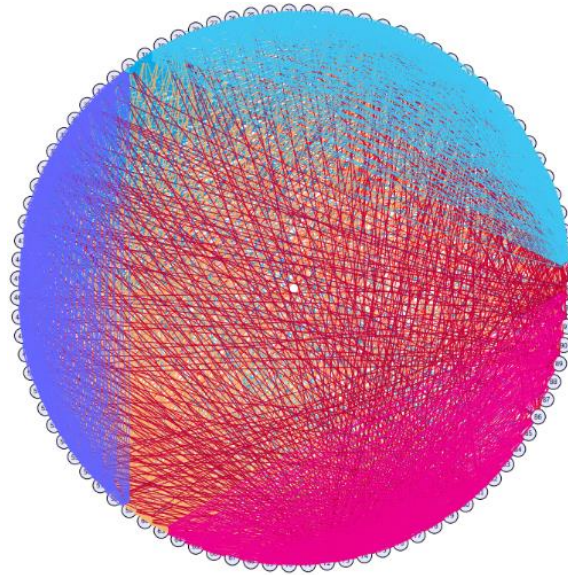


**Figure 2.** graph representation of student friendships

The graph represents the friendship status of each student in the Mathematics Study Program, Faculty of Mathematics and Natural Sciences, Mataram University, with a case study of Mathematics students from the Class of 2025. Each node represents a student labeled with their respective student ID, and the edges represent the friendship status of each student. To determine the influence of friendships on students' cumulative grade point averages, the degree of each node in the created graph representation will be calculated. The following is the definition of degree in a graph.

**Definition 1.** The degree of a vertex in an undirected graph is the number of edges connected to a single vertex, denoted as  $\deg(a)$  for  $a$  a member of the vertex set of a graph (Asmarani et al., 2022) .

The degree of each node is calculated by examining the Overleaf syntax used to create the graph. The degree of each node represents the number of friendships each student has. Next, the GPA of each student was obtained through the program administration via a formal request with permission from the program coordinator. In this study, the degree of each node is used as the independent variable, and the GPA of each student is used as the dependent variable. Subsequently, an analysis will be conducted to examine the influence of friendships on the cumulative GPA of mathematics students in the Class of 2025.

First, we examine the basic assumptions of regression, specifically the linearity test, to determine whether there is a linear relationship between the independent and dependent variables. The linear relationship between the degree of the graph and the GPA of the 2025 Mathematics program students is visualized using the following *scatter plot*.

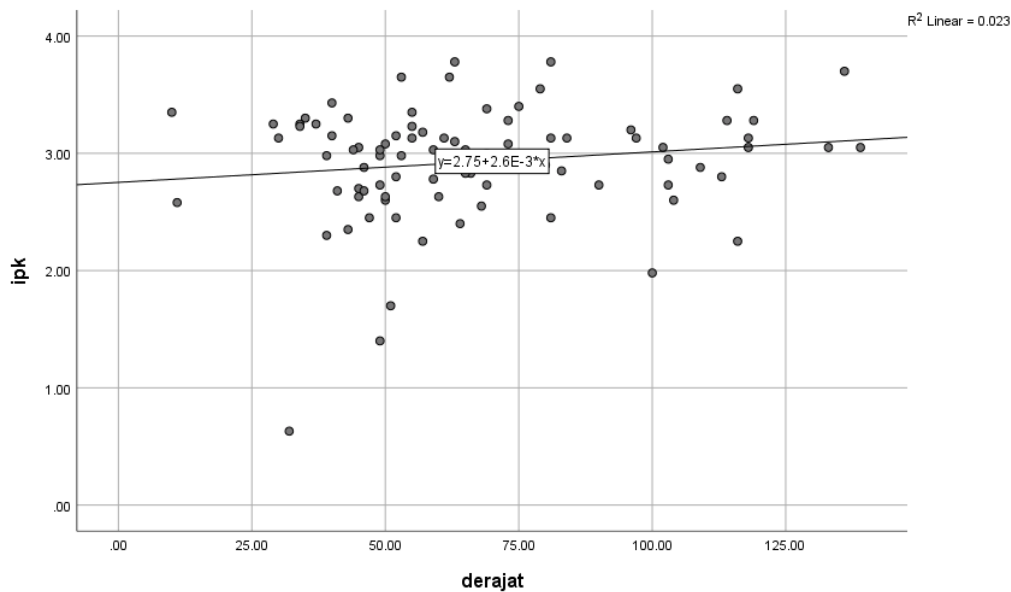


**Figure. 1** Scatter plot graph (Source: Software IBM SPSS Statistic)

Based on Figure 2, the data points show a pattern that tends to scatter and deviate from a straight line, so it can be concluded that the relationship between the degree of the graph and the GPA of mathematics students in the class of 2025 is weakly linear.

Second, classical assumption tests were conducted, consisting of a residual normality test and a heteroscedasticity test. The following are the results of the residual normality test using the *one-sample Kolmogorov-Smirnov* test.

$H_0$  : the data are normally distributed.

$H_1$  : The data are not normally distributed.

**Table 1.**Residuals for the normality test

| One-Sample Kolmogorov-Smirnov Test |                    |                         |
|------------------------------------|--------------------|-------------------------|
|                                    |                    | Unstandardized Residual |
| N                                  |                    | 86                      |
| Normal Parameters <sup>a, b</sup>  | Mean               | 0.0000000               |
|                                    | Standard Deviation | 0.48616802              |
| Most Extreme Differences           | Absolute           | 0.112                   |
|                                    | Positive           | 0.069                   |
|                                    | Negative           | -0.112                  |
| Test Statistic                     |                    | 0.112                   |
| Asympt. Sig. (2-tailed)            |                    | 0.009 <sup>c</sup>      |

Source: IBM SPSS Software (2026)

Based on the results of the *one-sample Kolmogorov-Smirnov* test, a significance value of 0.009 was obtained, which in this case is smaller than 0.05, resulting in a failure to accept the null hypothesis ( $H_0$ ), meaning the data are not normally distributed. Although the normality test indicated that the residuals were not normally distributed, simple linear regression was retained because the primary objective of this study was to examine the existence and direction of the linear relationship between vertex degree and students' GPA. Linear regression is generally considered robust to moderate violations of the normality assumption, particularly

when the sample size is sufficiently large. In this study, the sample consisted of 93 students, which is adequate for estimating the regression parameters (Demir, 2022). The next classical assumption test is the heteroscedasticity test. The heteroscedasticity test is conducted to determine whether the residuals of the regression model have constant variance or vary across all values of the independent variable. The following are the results of the heteroscedasticity test using the *Glejser* method, as shown in Table 2.

**Table 2.** Test for Heteroscedasticity Using the Glejser Method

| Coefficients <sup>a</sup> |                             |            |                           |        |       |
|---------------------------|-----------------------------|------------|---------------------------|--------|-------|
| Model                     | Unstandardized Coefficients |            | Standardized Coefficients | t      | Sig.  |
|                           | B                           | Std. Error | Beta                      |        |       |
| 1 (Constant)              | 0.483                       | 0.091      |                           | 5.285  | 0.000 |
| degrees                   | -0.002                      | 0.001      | -0.172                    | -1.604 | 0.113 |

Source: IBM SPSS Software (2026)

The *Glejser* test results showed a significance value of 0.113 ( $> 0.05$ ), indicating that there was no evidence of heteroscedasticity in the regression model, suggesting that the regression model remained appropriate for exploratory analysis. Therefore, the regression results were interpreted with caution and were intended to describe the linear association rather than to establish a causal relationship (N. K. Kumar, 2023).

Third, a parameter significance test was conducted to assess whether the parameters estimated in a model have a statistically significant effect on the dependent variable, so that it can be determined whether the relationship established by the model is truly meaningful or merely the result of random variation in the data (Yu et al., 2022). The parameter significance test consists of a partial test (t-test); the t-test is used to determine whether the regression model of the independent variables has a significant partial effect on the dependent variable, with the following hypotheses:

$H_0$ : There is no partial effect of degree on students' GPA.

$H_1$ : There is a partial effect of degree on students' GPA.

**Table 3.** Partial test coefficients (t-test)

| Coefficients <sup>a</sup> |                             |            |                           |        |       |
|---------------------------|-----------------------------|------------|---------------------------|--------|-------|
| Model                     | Unstandardized Coefficients |            | Standardized Coefficients | t      | Sig.  |
|                           | B                           | Std. Error | Beta                      |        |       |
| 1 (Constant)              | 2.752                       | 0.134      |                           | 20,543 | 0.000 |
| degrees                   | 0.003                       | 0.002      | 0.152                     | 1.410  | 0.162 |

Source: IBM SPSS Software (2026)

Based on Table 3, it can be seen that the partial t-test shows a significance value of 0.162. This indicates that there is no significant effect of the degree variable on the GPA, as shown by the significance level of 0.162 ( $> 0.05$ ), which indicates that friendship status has no significant effect on the GPA of mathematics students in the class of 2025.

Fourth, a coefficient of determination analysis was conducted to show the extent of the influence of the degree of vertex on the grade point average of student. The following are the results of the coefficient of determination analysis.

**Table 4** Model Summary

| Model Summary |                    |          |                   |                                |
|---------------|--------------------|----------|-------------------|--------------------------------|
| Model         | R                  | R Square | Adjusted R-Square | Standard Error of the Estimate |
| 1             | 0.152 <sup>a</sup> | 0.023    | 0.011             | 0.48905                        |

Source: IBM SPSS Software (2025)

Based on Table 4, the  $R$  value is 0.152 or 15.2%. This indicates that the relationship between the degree variable and the GPA variable is very weak. In other words, the degree variable has a correlation level of only 15.2% with GPA, so the influence or relationship between student friendships and the GPA of mathematics students in the class of 2025 tends to be weak. Furthermore, the *standard error of the estimate*, which represents the total error obtained in the study, is 0.48905.

The findings of this study differ from those reported by previous research, which found a very strong relationship between social factors and academic performance ( $R = 0.971$ ) (Utami et al., 2025). The discrepancy may be explained by differences in the research variables and analytical approaches. Previous studies examined multiple social factors, including family environment, friendship environment, and economic conditions, using perception-based questionnaire scores analyzed through multiple linear regression. In contrast, the present study focused exclusively on the structural characteristics of friendship networks using a graph theory approach. Rather than measuring students' perceptions of their friendships, this study analyzed actual friendship connections represented as a graph. Consequently, the resulting correlation ( $R = 0.152$ ) indicates that the structural pattern of friendship alone has only a very weak relationship with students' GPA. These findings suggest that academic performance is influenced not only by the existence of friendship networks but also by other social and personal factors that were beyond the scope of this study.

#### D. CONCLUSION AND SUGGESTIONS

Based on the results of this study, it can be concluded that friendship relationships modelled using a graph theory approach have a weak and statistically insignificant relationship with the Grade Point Average (GPA) of students in the 2025 cohort of the Mathematics Study Program at the University of Mataram. These findings indicate that the structural characteristics of students' friendship networks alone are insufficient to explain variations in academic performance. Although friendship networks may facilitate social interaction and access to learning support, academic achievement is likely influenced by a combination of other factors, such as learning motivation, family support, study habits, and socioeconomic conditions. This study demonstrates that graph theory provides an alternative approach for modelling friendship networks and contributes to understanding the relationship between social network structures and academic performance.

#### RECOMENDATIONS

Future studies are encouraged to involve a larger and more diverse sample, incorporate additional academic and social variables, and explore more comprehensive graph-theoretical to provide a deeper understanding of how friendship network structures relate to students' academic performance.

## ACKNOWLEDGEMENT

This research was funded by the PNPB (Non-Tax State Revenue) of the University of Mataram under the fiscal year 2026. The authors would like to express their gratitude to the University of Mataram for the financial support provided for this project.

## REFERENCES

- Aithal, P. S., Prabhu, S., & Aithal, S. (2024). Future of higher education through technology prediction and forecasting. *Poornaprajna International Journal of Management, Education, and Social Science (PIJMESS)*, 1(1), 1–50. DOI: <https://dx.doi.org/10.2139/ssrn.4901474>
- Ardana, A. P., Putri, S., Lestari, D., Wardhana, I. G. A. W., & Dharmayani, N. K. T. (2025). Boiling Point Modeling of Eugenol Compounds and Its Derivatives Using the Sombor Index and Reduced Sombor Index Approaches. *Journal of Fundamental Mathematics and Applications (JFMA)*, 8(2), 156–167. DOI: <https://doi.org/10.14710/jfma.v8i2.25725>
- Ardhyani, I. W. (2017). Mengoptimalkan Biaya Distribusi Pakan Ternak Dengan Menggunakan Metode Transportasi (Studi Kasus di PT. X Krian). *Teknika: Engineering and Sains Journal*, 1(2), 95–100. DOI: <https://doi.org/10.51804/tesj.v1i2.128.95-100>
- Asmarani, E. Y., Syarifudin, A. G., Wardhana, I. G. A. W., & Switrayni, N. W. (2022). The Power Graph of a Dihedral Group. *Eigen Mathematics Journal*, 4(2), 80–85. <https://doi.org/10.29303/emj.v4i2.117>
- Dalimunthe, H. A., Dewi, I. K., Yunita, Y., Faadhil, F., & Lubis, D. M. G. S. (2024). Building a supportive learning environment: The role of psychology in increasing student motivation and engagement. *OPSearch: American Journal of Open Research*, 3(4), 934–939. DOI: <https://doi.org/10.58811/opsearch.v3i4.107>
- Demir, S. (2022). Comparison of normality tests in terms of sample sizes under different skewness and kurtosis coefficients. *International Journal of Assessment Tools in Education*, 9(2), 397–409. DOI: <https://doi.org/10.21449/ijate.1101295>
- Dilekçi, A., & Karatay, H. (2023). The effects of the 21st century skills curriculum on the development of students' creative thinking skills. *Thinking skills and creativity*, 47, 101229. DOI: <https://doi.org/10.1016/j.tsc.2022.101229>
- Eid, M. I. M., & Al-Jabri, I. M. (2016). Social networking, knowledge sharing, and student learning: The case of university students. *Computers & education*, 99, 14–27. DOI: <https://doi.org/10.1016/j.compedu.2016.04.007>
- Ghebleh, M., Al-Yakoob, S., Kanso, A., & Stevanović, D. (2026). Reinforcement learning for graph theory, I: Reimplementation of Wagner's approach. *Discrete Applied Mathematics*, 380, 468–479. DOI: <https://doi.org/10.1016/j.dam.2025.10.021>
- Hall, J. A. (2019). How many hours does it take to make a friend? *Journal of social and personal relationships*, 36(4), 1278–1296. DOI: <https://doi.org/10.1177/0265407518761225>
- Kumar, N. K. (2023). Autocorrelation and heteroscedasticity in regression analysis. *Journal of Business and Social Sciences*, 5(1), 9–20.
- Kumar, S., Agarwal, M., & Agarwal, N. (2021). Defining and measuring academic performance of Hei students-a critical review. *Turkish Journal of Computer and Mathematics Education*, 12(6), 3091–3105.
- Kurniawan, R. (2016). *Analisis regresi*. Prenada Media.
- McCabe, J. M. (2019). *Connecting in college: How friendship networks matter for academic and social success*. University of Chicago Press.
- Nadeak, C. T. (2025). Analisis Jaringan Sosial Pengguna Perpustakaan Institut Teknologi Sumatera Berbasis Peminjaman Buku menggunakan Algoritma Leiden. *MATHunesa: Jurnal Ilmiah Matematika*, 13(3), 307–313. DOI: <https://doi.org/10.26740/mathunesa.v13n3.p307-313>
- Pavin Ivanec, T. (2022). The lack of academic social interactions and students' learning difficulties during COVID-19 faculty lockdowns in Croatia: The mediating role of the perceived sense of life disruption caused by the pandemic and the adjustment to online studying. *Social Sciences*, 11(2), 42. DOI: <https://doi.org/10.3390/socsci11020042>
- Read, B., Burke, P. J., & Crozier, G. (2020). 'It is like school sometimes': Friendship and sociality on

- university campuses and patterns of social inequality. *Discourse: Studies in the Cultural Politics of Education*, 41(1), 70–82. DOI: <https://doi.org/10.1080/01596306.2018.1457626>
- Sá, M. J. (2023). Student academic and social engagement in the life of the academy—a lever for retention and persistence in higher education. *Education Sciences*, 13(3), 269. DOI: <https://doi.org/10.3390/educsci13030269>
- Safetra, M. F. C., Desviona, N., Helmina, H., Rianti, A., & Prayogi, M. R. (2026). Penerapan teori graf dalam kehidupan sehari-hari. *Algoritma: Jurnal Matematika, Ilmu Pengetahuan Alam, Kebumian dan Angkasa*, 4(1), 52–68. DOI: <https://doi.org/10.62383/algoritma.v4i1.923>
- Schmidt, S. J. (2020). The importance of friendships for academic success. *Journal of Food Science Education*, 19(1), 2–5. DOI: <https://doi.org/10.1111/1541-4329.12176>
- Suryawan, A. D., & Putra, E. (2016). Analysis of determining factors for successful student's GPA achievement. *2016 11th International Conference on Knowledge, Information and Creativity Support Systems (KICSS)*, 1–7. DOI: [doi: 10.1109/KICSS.2016.7951403](https://doi.org/10.1109/KICSS.2016.7951403).
- Tyas, E. H., Sunarto, S., & Naibaho, L. (2020). Building superior human resources through character education. *TEST Engineering & Management*, 83, 11864–11873.
- Utami, Y., Vinsensia, D., Azmi, K., & Hakim, A. R. (2025). Analisis pengaruh faktor sosial terhadap kinerja akademik mahasiswa menggunakan regresi linier. *Jurnal SAINTIKOM (Jurnal Sains Manajemen Informatika dan Komputer)*, 24(1), 1–8. DOI: <https://doi.org/10.53513/jis.v24i1.10664>
- Yu, Z., Guindani, M., Grieco, S. F., Chen, L., Holmes, T. C., & Xu, X. (2022). Beyond t test and ANOVA: applications of mixed-effects models for more rigorous statistical analysis in neuroscience research. *Neuron*, 110(1), 21–35. DOI: [10.1016/j.neuron.2021.10.030](https://doi.org/10.1016/j.neuron.2021.10.030).
- Zhao, Y. (2023). *Graph theory and additive combinatorics: exploring structure and randomness*. Cambridge University Press.
- Zhou, D., Du, X., Hau, K.-T., Luo, H., Feng, P., & Liu, J. (2020). Teacher-student relationship and mathematical problem-solving ability: mediating roles of self-efficacy and mathematical anxiety. *Educational Psychology*, 40(4), 473–489. DOI: <https://doi.org/10.1080/01443410.2019.1696947>