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The student as true learner in the mathematics education study program

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Abstract

This study aimed to describe the character of a student with the greatest outdegree in Social Network Analysis (SNA) based on their group study partners. This research took 111 active students in the mathematics education study program at Universitas Mulawarman who were still taking courses. Research instrument in the form of a questionnaire name and NIM study friends. After forming the SNA structure, then select the node with the greatest outdegree and declare him/her as the true learner. This research used mixed methods, which means the researcher also interviewed the student declared as the node with the greatest outdegree. Based on the results, a student with NIM 2005046073 has the greatest outdegree of 22. This student was very active in asking her friends about the lecture material and their opinions regarding her understanding of the material. Furthermore, the student also gave tips on becoming a true learner on campus.

Keywords: Social network analysis, Outdegree, True learner, Mixed methods

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan karakter mahasiswa dengan *outdegree* terbesar dalam *Social Network Analysis* (SNA) berdasarkan teman sekelompoknya. Penelitian ini melibatkan 111 mahasiswa aktif program studi pendidikan matematika Universitas Mulawarman yang masih mengikuti perkuliahan. Alat penelitian berupa kuesioner berisi nama dan NIM teman sekelompok. Setelah membentuk struktur SNA, kemudian dipilih node dengan *outdegree* terbesar dan ditetapkan sebagai pembelajar sejati. Penelitian ini menggunakan metode campuran, yang berarti peneliti juga mewawancarai mahasiswa yang dinyatakan sebagai node dengan *outdegree* terbesar. Berdasarkan hasil penelitian, seorang mahasiswa dengan NIM 2005046073 memiliki *outdegree* terbesar yaitu 22. Mahasiswa ini sangat aktif bertanya kepada teman-temannya mengenai materi perkuliahan dan pendapat mereka mengenai pemahaman materi tersebut. Selain itu, mahasiswa tersebut juga memberikan tips untuk menjadi pembelajar sejati di kampus.

Kata kunci: *Social network analysis*, *Outdegree*, Pembelajar sejati, Metode campuran

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INTRODUCTION

The role of education extends beyond the simple transmission of knowledge. It also encompasses the holistic development of students, shaping their cognitive, emotional, and social capabilities. Education is organized as a process of acculturation and empowerment of students that lasts a lifetime (Boyadjieva & Ilieva-Trichkova, 2023; Mahendra et al., 2019; Williams, 2023). This process also applies to students in college. So that the main task of students is to study and seek knowledge so that it can be helpful after graduating from college (Hairani, 2018). In higher education, this becomes even more crucial, as universities are spaces where students are expected to become independent thinkers, critical analysts, and problem solvers. The aim is not merely to prepare students for the workforce but to mold them into adaptable individuals who can contribute meaningfully to society.

Many factors are often used as a benchmark for educational success. One of them is by looking at the success of the lecture process in achieving its objectives. Another factor that is very important at this time is the motivation of students to prepare themselves to start a teaching and learning process. Students have a driving force to carry out learning activities in higher education to achieve their desired learning goals. That drive or mover is called motivation (Masni, 2017).

One of the most significant challenges in modern education is sustaining student motivation over the long term. Motivation, which can be intrinsic (driven by an internal desire to learn) or extrinsic (motivated by external rewards like grades or future job prospects), is a key factor in educational success. Studies have shown that students who are intrinsically motivated are more likely to engage deeply with learning materials, retain information more effectively, and achieve long-term success. In contrast, those relying solely on extrinsic motivation may struggle to maintain enthusiasm over time. Therefore, higher education institutions must create an environment that fosters both types of motivation, encouraging students to see learning as an inherently rewarding and transformative process (Johansson & Felten, 2014).

Mathematics, which is still difficult for students, requires prospective teacher students to have mathematical communication skills (Pantaleon et al., 2018; Uyen et al., 2021). Mathematical communication skills are essential for a mathematics teacher as a facilitator and mediator of learning. Teachers can change the view of mathematics that is difficult and very abstract for students with the right way of delivery. Future teachers must not only understand mathematical theories but also be skilled in making these theories accessible and relatable to students. They need to communicate complex ideas in ways that demystify the subject, making it more engaging and less intimidating. Moreover, mathematical communication goes beyond just explaining concepts; it also involves creating an interactive and participatory classroom atmosphere. Teachers who can encourage dialogue and critical thinking among students help demystify mathematics and demonstrate its relevance in real-world

contexts (Jurdak, 2016; Peter, 2012). Prospective teachers must be equipped with these communication strategies early in their training, as they play a crucial role in how future generations will perceive and engage with the subject. Therefore, prospective mathematics teacher students must be able to take advantage of the time while in college to practice their mathematical communication skills both orally and in writing. So, it is appropriate for these students to become true learners (Rizta & Antari, 2018).

Students can hone mathematical communication skills by teaching math material to their study partners. The process of teaching mathematics requires prospective teacher students to be able to communicate their understanding of mathematics so that this understanding can be understood by others. A student-teacher candidate can improve his mathematical knowledge by sharing his mathematical ideas. Communication has a powerful relationship with other mathematical processes, where communication is needed to complement each mathematical process. (Fisher, 2006; Kosko & Wilkins, 2010; Lagur et al., 2018; Makur et al., 2018)

True learning requires students to be able to master mathematics from primary to advanced material and summarize ideas when solving a math problem. Students can sharpen their mathematical abilities while studying with their study partners. The social structure of students in studying with their friends can be formed through patterns formed from graphs that represent Social Network Analysis (SNA). This graph can be constructed based on a matrix arranged based on research instruments. An in-depth analysis of associative group learning patterns demonstrated how prospective mathematics teachers naturally formed supportive academic environments (Rizki et al., 2026). The investigation utilized directed graph mapping to trace the vital flow of information among the students.

Research on SNA on student data has been carried out a lot like Rabbany et al. (2014) to analyze the structure of interactions between the students in Online Discussion Forums; Nkomo et al. (2020) analyzed transcripts of discussions on social media (Facebook) that students generated on the value of lecture recordings; and Benítez-Andrades et al. (2020) using Social network analysis for personalized characterization and risk assessment of alcohol use disorders in adolescents using semantic technologies. The application of social network analysis methods is highly effective for designing discussion groups that enhance students' mathematical communication (Wijayanto et al., 2023). Through structured network mapping, educators can predict students' academic performance in advanced mathematics with greater precision (Sabanal et al., 2024). Moreover, the peer-learning environment fostered within social networks significantly facilitates increased self-efficacy (Woreta et al., 2025). The closeness and sense of belonging that develop within these study groups serve as valuable assets for students to persevere and thrive in the fields of science and mathematics (Pedersen et al., 2025). Collectively, these various innovative approaches have great potential to enhance the overall effectiveness and quality of learning (Lu et al., 2025).

METHODS

This research was mixed research with the aim to describe the character of a student with the greatest outdegree in Social Network Analysis (SNA) based on their group study partners. This research was conducted in February 2023 and involved 111 active students in the mathematics education study program at Universitas Mulawarman who were still taking courses at that time. The research instrument was a questionnaire containing the names and NIM (ID) of study friends.

This research began by constructing an adjacency matrix of students. Based on this matrix, it can be determined which node was the node with the greatest outdegree. In-depth interviews were conducted with a student labelled the greatest outdegree. In addition, the interview data were supported by several informants through purposive sampling and snowball sampling. The node with the largest outdegree can be seen visually through the graph that forms the SNA structure created by Gephi 0.10.

RESULTS AND DISCUSSION

After collecting all the questionnaires, the next step was to create an adjacency matrix. The following was the matrix for nodes that represented NIMs from students who often learned to whom their NIMs were.

$$\begin{bmatrix} 0 & 1 & 1 & \dots & 0 \\ 1 & 0 & 0 & \dots & 0 \\ 0 & 0 & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 0 \end{bmatrix} \quad (1)$$

This matrix was 111x111 in size. NIM sorted this matrix index. A value of 0 in row *i*, column *j* in the matrix meant that students in row *i* did not learn from students in column *j*. This matrix formed a directed graph. Of course, this matrix was unlikely to be orthogonal. Then, this representation matrix could construct a graph, as shown in Figure 1. The arrows were edges that indicated a student learned from another student. NIM represented the nodes in this graph. Through the network visualization in this figure, the patterns of group study relationships were effectively captured. The sociogram displayed showed the direct connections formed when a student learned from a classmate. The structural pattern of these directed edges helped identify the key individuals who consistently shared their mathematical knowledge.

After the researchers formed the SNA structure, the next step involved selecting the node with the largest outdegree to be identified as the true learner. In addition to visualizing it through the graph in Figure 1, the exact outdegree for the ith node was calculated by adding up all the elements in the corresponding ith row. Table 1 presents the five nodes with the largest outdegrees, which also display scattered degree values. Based on Table 1, the student with NIM 2005046073 achieved the largest outdegree. Her total degree represented the totality of her interactions and communication volume, illustrating her extensive social visibility and strong learning initiative. This high connectivity highlighted her collaborative nature and her significant influence in

facilitating mathematical communication. Furthermore, her highest eccentricity value demonstrated her furthest social reach and flexibility in connecting with peers outside her immediate circle. This strategic position allowed her to bridge communication gaps and reach even the most marginal members of the network, acting as a highly effective conduit for academic information. Consequently, she was officially declared as the true learner.

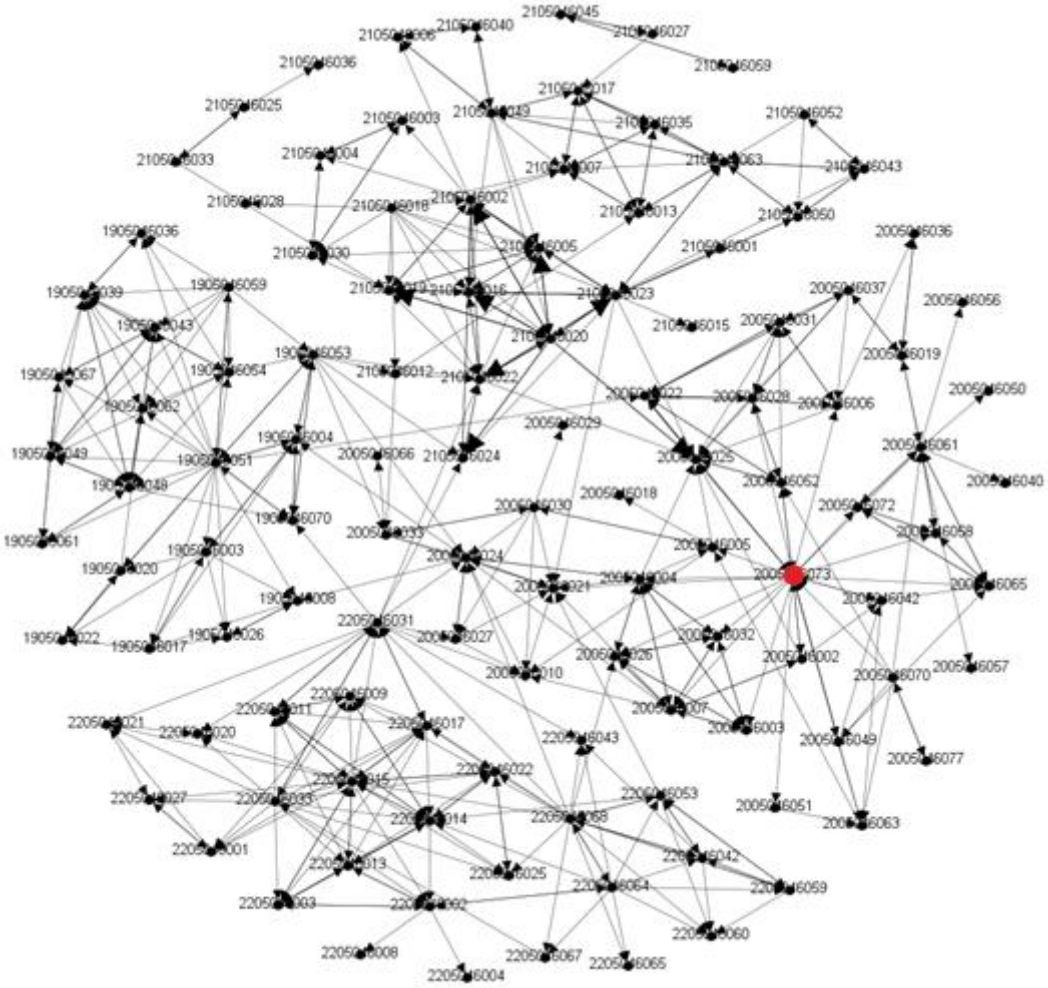

Figure 1. Directed graph of student group study interaction

Table 1. The Five Students with The Biggest Degrees and Outdegrees

NIM	Indegree	Outdegree	Degree	Eccentricity
2005046073	7	22	29	8
1905046051	4	20	24	5
2205046015	8	14	22	7
2105046023	8	14	22	6
2205046068	4	16	20	6

Furthermore, the student with NIM 2005046073 was further interviewed to ensure this algorithm was successful. She had understood and answered the questionnaire instrument correctly. This student was very active in asking her friends about the lecture material and their opinions regarding her understanding of the

material. She did this to ensure that her lecture material was complete and the concepts she had understood were appropriate. She usually did it when approaching midterm and final semester exams. Apart from being very active in asking her friends, she also asked for questions that had been previously tested on seniors aged 2 years and above.

This student always asked someone who was considered to have complete notes and someone who was good at the subject she wanted to master. Apart from that, she also asked other people who had different opinions so that she could conclude the material she had studied. Of course, this student was always rejected by her friends when she asked for answers to assignments from the course, but she could be accepted if she asked for an understanding of the course material. At that time, her learning resources were printed books, electronic books, journals, YouTube, and material on mathematics websites. Furthermore, this student, who has a GPA of 3.34, gave tips on becoming a true learner on campus, i.e. 1) Make sure to enter class every meeting and get high marks; 2) Dare to ask questions during lectures and outside the classroom; 3) Be an active student during lectures; 4) Don't do assignments when the deadline is approaching but long before the day of assignment collection; and 5) Adding friend relations.

Before conducting the interview, based on observations when the first and fifth researchers were lecturers of the course and the opinions of their fellow students as informants, it was found that students with NIM 2005046073 had self-efficacy, independent learning, strong motivation to learn, good numeracy and mathematical communication skills, and kinesthetic learning styles. These things make this student part of the group of students with an above-average GPA. This statement is supported by the research results of Suryani et al. (2020), which show that self-efficacy and learning independence positively influence learning outcomes. Then Fadila et al. (2021) added that learning independence has an essential role in student learning outcomes, so that students can increase their learning independence and their learning outcomes can increase. Then, in line with the results of research by Widyastuti et al. (2021), students with a high level of self-efficacy develop oral mathematical communication skills, which tend to increase. Students' learning success was closely related to their self-efficacy and communication within their learning social networks. Recent findings emphasized that students with higher levels of social interaction tended to have more flexible mathematical communication (Ningsih et al., 2025; Nuraina & Mursalin, 2018). The support of real-world learning approaches also strengthened their overall mathematical understanding. Furthermore, independence and self-confidence empowered students to face problem-solving challenges with courage (Amri et al., 2020). The increase in numeracy literacy and active engagement became vital indicators of their academic achievement (Álvarez-Huerta et al., 2021).

Street et al. (2024) confirmed that mathematics self-efficacy is strongly associated with learning behaviors, performance, and students' future career choices. Their review highlighted the need for mixed-methods studies that continue to focus on MSE as a multidimensional and dynamic concept. He & Wen (2025) examined the

mediating roles of self-efficacy and learning motivation in the relationship between peer relationships and online learning engagement, finding that peer relationships significantly enhanced online learning engagement through the mediating effects of self-efficacy. Their results align with our findings that the student with the greatest outdegree exhibited high self-efficacy and actively utilized peer relationships to support her learning.

This student has the ability to complete academic assignments with varying degrees of difficulty, determine planning and self-regulation in completing academic assignments, have confidence in their business abilities in realizing the expected learning goals, and have confidence in their ability to persevere in the efforts made to achieve learning goals. Thus, this female student is included in the self-efficacy indicator mentioned by Monika & Adman (2017). These findings were supported by Hernández de la Hera et al. (2023), who showed that self-efficacy had a strong positive relationship with students' attitudes toward mathematics and academic performance, while mathematics anxiety had a negative impact. Furthermore, Qiu et al. (2023) in their innovative study, used a group dynamics model to investigate the process of peer learning and found that an optimal level of teacher participation could substantially increase the effectiveness of peer learning.

Students with high self-efficacy have good numeracy literacy skills. These results are in line with Salsabilah & Kurniasih (2022) and Sari et al. (2019), which show that based on the level of self-efficacy, if self-efficacy is high, learning outcomes in mathematics are also high. With high mathematics learning outcomes, students' understanding of the questions is also high. Understanding this good question can have a good influence on students' numeracy literacy skills. These students' low understanding of mathematics affects their numeracy literacy abilities (Salvia et al., 2022).

Based on the results of interviews with the student and observations, it was also shown that she could use her social skills to ask her friends and several close seniors for lecture notes. She knows how to ask other people nicely and politely. This is in line with the opinion of Izzati (2016) that students who have high social skills have a good social environment and are liked by many people because they can control themselves, can convey ideas well, discuss fluently, can work together, be good listeners, can respect others, and are active in organizations. She is one of the students classified as a true learner. We hope they can maintain their character and achieve great success after graduation.

CONCLUSION

Social Network Analysis (SNA) helps to create social structures in the case of student group study partners. The node with the greatest outdegree was a student with NIM 2005046073, and she was declared as the true learner. This student was very active in asking her friends about the lecture material and their opinions regarding her understanding of the material. She also has self-efficacy, learning independence, and is

highly motivated to learn mathematics in college, good numeracy and mathematical communication skills, and good social skills.

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