

The Relationship between Teacher-student Relationship and Mathematical Literacy of Medical Students: the Mediating Role of Self-Efficacy

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Abstract: The purpose of this study is to explore the relationship between the teacher-student relationship and mathematical literacy of medical students, as well as the mediating role of self-efficacy, so as to provide theoretical basis for improving mathematical literacy of medical students. In December 2023 to March 2024, a self-designed questionnaire was used to survey 806 medical students at a certain medical university in Shandong Province. The mathematical literacy of medical students was positively correlated with the teacher-student relationship and self-efficacy ($P < 0.01$). The results of the mediation model showed that the direct and indirect effects of the teacher-student relationship on mathematical literacy were significant, with the direct effect accounting for 67.35% of the total effect and the indirect effect through self-efficacy accounting for 32.65%. By establishing a good teacher-student relationship and improving the self-efficacy of medical students, their mathematical literacy can be improved.

Keywords: Medical Students; Mathematical Literacy; Teacher-Student Relationship; Self-Efficacy

1. Introduction

Mathematical literacy refers to the ability and inclination to observe, analyze, and solve problems using mathematical perspectives, thinking processes, and methods [1]. It encompasses not only the mastery of mathematical knowledge but also its application and comprehension. In contemporary society, mathematical literacy

enables university students to better understand and address complex issues. Furthermore, the process of learning mathematics, which involves continuous logical reasoning and proof, subtly cultivates students' logical thinking abilities [2]. Medical students with advanced mathematical literacy can more effectively employ statistical methods and mathematical models to handle and analyze experimental data, thereby enhancing the quality and efficiency of research. Moreover, mathematical literacy fosters innovative thinking and creativity among students, with innovation being crucial for advancing scientific progress.

According to attachment theory in psychology, the teacher-student relationship plays a critical role in the learning process [1]. A positive teacher-student relationship can facilitate better learning and consequently improve academic performance. Emotional support within this relationship can boost students' engagement in learning, and attachment to teachers helps foster a positive learning attitude, enhancing learning outcomes. The psychological resilience of students is closely linked to their academic achievements; a supportive teacher-student relationship can bolster resilience, aiding students in overcoming academic challenges and maintaining a positive learning attitude, which in turn improves academic performance. Research indicates that teacher-student relationships impact students' learning engagement through their self-efficacy [3]. Self-efficacy refers to an individual's subjective judgment and belief in their capability to successfully complete a task through effort [4]. Studies have shown a significant positive correlation between self-

efficacy and academic performance. Students with high self-efficacy tend to choose challenging tasks and set achievable learning goals, which enhances their motivation and enthusiasm, thereby improving academic performance. Furthermore, these students actively manage and monitor their learning processes, promptly addressing and resolving issues to achieve their goals. This proactive approach also contributes to increased learning efficiency and academic success [5]. Research has also found that academic performance influences self-efficacy; excellent performance boosts self-efficacy, reinforcing students' belief in their abilities, which creates a positive feedback loop and further advances their academic progress [6].

2. Subjects and Methods

2.1 Research Subjects

From December 2023 to March 2024, a survey was distributed to 860 undergraduate students at a medical university in Shandong Province. Out of these, 54 questionnaires were deemed invalid, leaving 806 valid responses, resulting in an effective response rate of 93.72%. Among the respondents, 752 were first-year students, representing 93.30% of the total, with the remaining 54 students from other academic years, indicating a predominance of first-year participants. In terms of gender, there were 518 female and 288 male respondents. Geographically, 273 were from urban areas, 198 from towns, and 335 from rural regions. By major, there were 250 students in clinical medicine, 225 in dentistry, 60 in anesthesiology, 90 in medical imaging, and 181 in other public health and related fields.

2.2 Survey Instruments

The demographic survey included four questions covering gender, academic year, place of residence, and major. The mathematical literacy assessment scale, derived from the International Student Assessment Program (PISA) organized by the Organisation for Economic Co-operation and Development (OECD), comprised five questions selected from past examinations. These questions reflected various aspects of mathematical literacy, including computational proficiency, abstract thinking, logical reasoning, intuitive visualization, mathematical

modeling, and data analysis. A correct answer earned 1 point, with no points awarded for incorrect or missing answers.

Based on relevant literature, a survey was independently developed to investigate factors influencing mathematical literacy among medical students. This survey is divided into three sections: the mathematical self-efficacy scale, the teacher-student relationship scale, and environmental factors. The self-efficacy scale consists of six items related to students' confidence in their mathematical learning abilities and their belief in their potential to excel in mathematics, such as "I can master mathematics if I want to" and "With enough effort, I can excel in mathematics." The Cronbach's α coefficient for this scale is 0.801. The teacher-student relationship scale also includes six items, focusing on the dynamics between mathematics teachers and students, such as "The mathematics teacher is fair to every student" and "The mathematics teacher maintains good relationships with students." The Cronbach's α coefficient for this scale is 0.876, with responses rated on a Likert scale from 1 to 5.

2.3 Statistical Methods

Descriptive statistics, analysis of variance, reliability and validity testing, and correlation analysis (Spearman correlation) were conducted using SPSS 29.0, with a two-tailed significance level of $\alpha = 0.05$. A mediation model was constructed using Model 4 from Hayes' SPSS Process 4.2.

3. Results

3.1 Current Situation Analysis

In the mathematical literacy assessment, a score of 4 or more correct answers out of 5 is considered excellent, 2-3 correct answers is average, and 1 or fewer correct answers is poor. The survey results indicate that 416 individuals achieved an excellent rating, comprising 51.6% of the sample, 278 individuals had average mathematical literacy, accounting for 34.5%, and 112 individuals were rated as poor, representing 13.9%. Overall, the mathematical literacy of the medical students surveyed is quite commendable. Analysis of variance reveals no significant differences in mathematical literacy, self-efficacy, or teacher-student relationships across different genders

($P > 0.05$). There are no differences in mathematical literacy or self-efficacy based on students' place of residence, though differences in teacher-student relationships are noted ($P = 0.04$). Variations in mathematical literacy

and teacher-student relationships are observed across different majors ($P > 0.05$).

3.2 Descriptive Statistics and Correlation Analysis

Table 1. Correlation Analysis of Teacher-Student Relationship, Self-Efficacy and Mathematical Literacy

Variable	Score($\bar{x} \pm s$)	mathematics literacy	teacher-student relationship	self-efficacy
Mathematical literacy	25.6 $\pm$ 2.69	1.000		
Teacher-student relationship	25.38 $\pm$ 1.93	0.132**	1.000	
self-efficacy	22.14 $\pm$ 2.55	0.142**	0.419**	1.000

Correlation analysis reveals a significant positive relationship between mathematical literacy test scores and both self-efficacy and teacher-student relationships, as detailed in Table 1. Specifically, the correlation coefficients are 0.142 between mathematical literacy and self-efficacy, and 0.132 between mathematical literacy and teacher-student

relationships. The correlation between self-efficacy and teacher-student relationships is 0.419, with all correlations being statistically significant.

3.3 Mediation Model Analysis of Self-Efficacy, Teacher-student Relationships, and Mathematical Literacy

Table 2 Path Analysis of Mediation Model

Regression equation		fitting index			coefficient significance			
Dependent variable	Independent variable	R	R ²	F	β	SE	t	P
Mathematical literacy	Teacher-student relationship	0.132	0.017	14.174***	0.049	0.013	3.765	$P < 0.001$
self-efficacy	Teacher-student relationship	0.419	0.176	171.4***	0.553	0.042	13.092	$P < 0.001$
Mathematical literacy	Teacher-student relationship	0.163	0.026	10.90***	0.032	0.014	2.283	$P < 0.05$
	self-efficacy				0.029	0.011	2.74	$P < 0.01$

*** $p < 0.001$ ** $p < 0.01$, $p < 0.05$

Table 3 Analysis of Mediating Effects

Effect type	path relationship	Effect size (95%CI)	BootSE	Effect ratio (%)
Total effect		0.049 (0.023~0.074)	0.013	
Direct effect	Teacher-student relationship $\rightarrow$ Math literacy	0.033 (0.045~0.060)	0.014	67.35%
Mediating effect	Teacher-student relationship $\rightarrow$ Self-efficacy $\rightarrow$ Mathematical literacy	0.016 (0.005~0.030)	0.006	32.65%

Using teacher-student relationships as the independent variable (X), mathematical literacy as the dependent variable (Y), and self-efficacy (M1) as the mediating variable, with major and place of residence as control variables, the results demonstrate that teacher-student relationships have a significant total effect on mathematical literacy ($\beta = 0.049$, $P < 0.001$). Teacher-student relationships positively predict self-efficacy ($\beta = 0.553$, $P < 0.001$), and the direct effect of teacher-student relationships on mathematical literacy is significant ($\beta = 0.032$, $P < 0.05$). Self-efficacy

also significantly predicts mathematical literacy ($\beta = 0.029$, $P < 0.01$), as detailed in Table 2.

As illustrated in Table 3, the 95% confidence intervals for both the mediation and direct effects do not include zero, indicating that both effects are significant. The direct effect of teacher-student relationships on mathematical literacy is substantial, constituting 67.35% of the total effect, while the mediating effect of mathematical self-efficacy accounts for 32.65%, indicating that self-efficacy partially mediates the relationship between teacher-

student relationships and mathematical literacy

4. Discussion

This study reveals that students from different residential areas exhibit variations in their relationships with teachers, and there are discrepancies in mathematical literacy and teacher-student relationships across different disciplines. The differences in teacher-student relationships among medical students from various residential areas may stem from a complex interplay of factors such as urban-rural educational resources, pedagogical methods, and family background. Students from urban families, benefitting from greater educational resources and opportunities, likely engage in more frequent and profound interactions with their teachers, fostering closer teacher-student relationships. Conversely, students from rural backgrounds, facing relative scarcity of educational resources, may have fewer opportunities for communication with teachers, resulting in more distant teacher-student relationships [7]. Disparities in mathematical literacy among medical students across different disciplines may be attributed to varying demands and emphases on mathematical knowledge within each field. For instance, fields such as clinical medicine and pharmacy may require more advanced mathematical knowledge and analytical skills, whereas nursing and public health may place relatively less emphasis on mathematics. This divergence leads to uneven development of mathematical literacy among medical students across disciplines. In terms of teacher-student relationships, differences among students in various fields may be influenced by factors such as the characteristics of the profession, learning styles, and teaching methodologies. For example, some educators might prioritize interaction and communication with students, thereby fostering better teacher-student relationships, while others might focus more on knowledge transmission, resulting in less engagement and consequently more distant relationships.

The study identifies teacher-student relationships as a direct factor influencing medical students' mathematical literacy and also as having an indirect effect through self-efficacy. Positive teacher-student relationships provide emotional support and a sense of

security for students. When students perceive care and support from their teachers, they are more likely to develop a positive attitude toward learning, thereby investing greater effort in subjects like mathematics. Positive interactions between teachers and students can stimulate intrinsic motivation to learn; recognition and praise from teachers for students' efforts and achievements can make students feel that their hard work is rewarded, leading to increased effort in studying mathematics. The quality of teacher-student relationships significantly impacts students' self-efficacy. When students have harmonious relationships with their teachers, they are more likely to receive positive feedback and encouragement, which boosts their confidence in learning mathematics. This enhanced self-efficacy helps students persevere in the face of mathematical challenges, thereby improving their mathematical literacy [8]. Furthermore, students' self-efficacy influences their attribution styles; those with high self-efficacy are more inclined to attribute failures to insufficient effort rather than a lack of ability, fostering a positive attitude toward mathematical learning [9].

Schools should regularly conduct teacher training programs, particularly focusing on establishing effective teacher-student relationships, to enhance teachers' pedagogical skills and interpersonal abilities. Curriculum design should integrate mathematical courses with practical medical applications to increase the relevance and appeal of mathematics, thereby boosting student interest and motivation. Establishing counseling centers to help students manage academic stress and improve self-efficacy will further enhance mathematical literacy. Teachers should proactively communicate with students to understand their needs and challenges, offering personalized guidance and support; employing interactive teaching methods such as case studies and group discussions to stimulate student interest and engagement; and providing timely feedback and encouragement to acknowledge students' progress and achievements, thereby bolstering their self-efficacy and motivation to learn. Mathematics teachers should strengthen the interaction between teachers and students, not only in class, but also after class, set up math discussion groups to discuss math problems

with students regularly, which can not only enhance students' understanding of mathematical theoretical knowledge, but also strengthen the connection between teachers and students. Teachers should learn to stimulate students' interest in learning. Teachers can stimulate students' interest in math through interesting math problems or math games. When students have enthusiasm for math learning, they will be more involved, thus improving the learning effect. Pay attention to the differences between students and provide personalized teaching; each student has their own learning style and pace [10].

5. Conclusion

This study finds that there are differences in teacher-student relationship among students from different family locations, and differences in mathematics literacy and teacher-student relationship among different majors. It is found that the teacher-student relationship is a direct factor affecting the mathematical literacy of medical students, and it can also indirectly affect the mathematical literacy through self-efficacy, and the direct effect is greater than the indirect effect. The teacher-student relationship plays an important role in cultivating students' mathematical literacy, and a good teacher-student relationship can provide students with emotional support and a sense of security. When students feel cared for and supported by their teachers, they are more likely to develop a positive attitude towards learning and thus put more effort into subjects such as math.

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