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The Role of Mathematical Self-Efficacy in the Relationship Between Mathematical Resilience and Academic Achievement in Mathematics Among Humanities Students

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ABSTRACT

The present study aims to investigate the mediating role of mathematical self-efficacy in the relationship between mathematical resilience and academic achievement in mathematics among humanities students. This research employs a descriptive and correlational design. A sample of 282 eleventh and twelfth-grade humanities students (138 girls and 144 boys) from Tehran was selected using Simple Random sampling. The participants completed the Mathematical Self-Efficacy Scale by Asher and Pajares and the Mathematical Resilience Scale by Kooken et al. Their mathematical achievement was measured using the average of their last two final grades. Structural equation modeling was utilized for data analysis. The results indicate that both mathematical resilience and mathematical self-efficacy have a direct effect on the mathematics achievement of humanities students. Additionally, the data analysis revealed a significant relationship between mathematical resilience and academic achievement in mathematics, mediated by mathematical self-efficacy. Therefore, mathematical resilience and self-efficacy play a crucial role in the academic achievement in mathematics of humanities students. Targeting these two components in mathematics education can effectively enhance the academic performance in mathematics of humanities students.

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Introduction

Despite the special role and importance of mathematics in education and its application in today's world, this subject is generally not attractive for students. Research shows that students face obstacles, problems, fear and anxiety in learning mathematics, which leads to their hatred of mathematics and ultimately avoid learning and doing mathematics (Morales & DiNapoli, 2018; Ashcraft, 2002).

It is evident that effective mathematics education and academic progress necessitate the identification of obstacles that hinder students' learning in this subject (Taghizadeh et al., 2014). Academic achievement in the education system is a crucial issue that attracts a significant portion of research each year. In an attempt to improve students' cognitive and emotional outcomes in mathematics and learning, educational psychologists and mathematics teachers have sought to identify variables (personal and environmental) that can be manipulated to achieve academic success, particularly in mathematics (Chief Inspector's Report, 2005, 2006, and 2007, as cited in Adedeji & Ayotola, 2009). According to most educational psychologists, cognitive factors such as intelligence are prerequisites for learning mathematics. However, Suinn & Edwards (1982) and Bassant (cited in Zaki, 2011) provide evidence that more than half of academic success in mathematics can be explained by emotional variables, and motivational factors such as beliefs, attitudes, values, and anxiety also play a role in this regard. Therefore, conceptual understanding and effective application of mathematical knowledge require the presence of factors such as motivation and interest, meaningful attitudes towards mathematics, and self-efficacy, which can be good predictors of mathematics learning. These factors can also be associated with resilience in mathematics, which leads to increased perseverance and stress management in the face of challenges.

Resilience is often defined as a process, capacity, or outcome of successful adaptation in the face of adversity or risk (Allan et al., 2013; Mansfield et al., 2016). The educational process for students is filled with ups and downs, each period with its own set of challenges. Individuals who demonstrate greater resilience in response to these challenges and manage stress more effectively are known as resilient individuals (Bidkhori, 2013).

Mathematical resilience is an important concept in mathematics education as most students find learning mathematics to be challenging. Mathematical resilience is the ability of an individual to cultivate self-belief when faced with obstacles, pressures, and difficulties in learning mathematics. For resilience to have meaning, there must be some form of adversity or difficulty that is followed by a positive outcome. In the context of mathematics, adversity and hardship can take many forms, including failing grades, effort beyond a student's tolerance, boredom and laziness, embarrassment from poor performance, low-quality curriculum or instruction, and unsupportive teacher-student or student-student interactions (Yeager & Dweck, 2012). Mathematical resilience also shares many characteristics with other psychological constructs such as self-efficacy, optimism, motivation, and self-confidence (Lee & Johnston-Wilder, 2017).

Math resilience consists of three main dimensions (Kooken et al.,2015).

1.Value: This dimension relates to the extent to which students are aware of the importance of learning mathematics for achieving their goals and its role in their academic success and future life.

2.Struggle: This dimension refers to students' belief in the need for effort and persistence in learning mathematics, even in the face of obstacles and difficulties. This belief helps students to persevere in the face of challenges and continue to strive for learning.

3.Growth Mindset: This dimension refers to students' belief in the dynamic and expandable nature of their mathematical abilities. Students with a growth mindset believe that they can improve their math skills through effort and persistence and reach higher levels of understanding and mastery in this subject.

In addition to these three dimensions, subsequent research has shown that being part of a supportive mathematics learning community can also be considered a component of math resilience (Lee & Wilder, 2017). This supportive community can include teachers, classmates, parents, and other individuals who encourage, guide, and support students in their mathematics learning process.

In the study by Kooken and colleagues (2013), the theoretical basis for the factors of mathematical resilience was introduced as motivational and especially attitudinal dimensions. Early studies on math attitude and its role in academic achievement began with the research of Aiken (1961 and 1979). The

findings of these studies showed that math attitude is a multidimensional construct that includes enjoyment of engagement in math tasks, individuals' beliefs about the value and importance of math, and the level of fear of facing situations that require the application of mathematical knowledge (Aiken, 1979).

Understanding the dimensions and components of math resilience can help teachers and educational planners design and implement effective instructional programs to promote this skill in students. By strengthening math resilience in students, they can be given the motivation and confidence they need to overcome the challenges of learning mathematics and achieve success in this subject (wilder & Lee,2024). Research has consistently identified resilience as a key factor contributing to students' success in mathematics (Lee & Wilder, 2017; Ayodele, 2011). Miranda & Agtarap (2022) investigated the role of mathematical resilience as a mediating between mathematics self-concept and mathematics achievement. Their study found that among the dimensions of resilience, struggle had the highest average score, followed by value and growth mindset. This suggests that struggle play a crucial role in mathematics learning, and that students also need to view mathematics as a valuable subject to succeed in it.

Self-efficacy refers to an individual's confidence in their ability to successfully perform a specific task (Bandura, 1977). Math self-efficacy is the belief in one's abilities to perform specific mathematical tasks, such as "I can solve this math problem" (Bandura, 2012). Research has shown that self-efficacy beliefs are important mediators for all activities related to achievement (Hejazi & Naghsh, 2007). Greene et al (2004) identified self-efficacy as a significant predictor of academic performance in specific domains.

Individuals who demonstrate mathematical resilience often experience a higher sense of self-efficacy (Schweinle & Mims, 2009; Yeager & Dweck, 2012). Research has shown that mathematical self-efficacy beliefs are associated with mathematics achievement (Chang, 2012; Kang, 2009).

In a study by Alimoradi & Hamidi (2014), where mathematical self-efficacy was considered as a mediator between mathematical self-concept and optimistic perception of mathematics with mathematical achievement, no significant relationship was observed. Additionally, Farhani & Karimi (2002) found a significant relationship between self-efficacy as a mediating variable between attitude and mathematics performance. In this case, attitude towards mathematics affects mathematical self-efficacy and ultimately leads to increased mathematics performance. Furthermore, Kung & Lee (2016) found a significant mediator role of mathematical self-efficacy in the relationship between parental involvement and mathematics achievement.

Based on the research conducted and considering the importance and novelty of this topic, this study investigates the relationship between mathematical resilience and mathematics achievement in humanities students, with the mediating role of mathematical self-efficacy.

Method

The present study is descriptive-correlational research. The statistical population of this study is the eleventh and twelfth grade humanities students in Tehran in the academic year 2022-2023.

Sample and Sampling Method

The participants in this study are 282 students from public, non-profit and state-owned schools in Tehran who were selected using the simple random sampling method. The sample size was determined based on the opinions of experts and specialists (Kline, 2016; Hatcher, 1994 & Suhr, 2006) to be 300 people; however, due to the dropout of the subjects, the sample size was considered 310. After reviewing and removing the questionnaires that were not completed in full, the final sample was reduced to 282.

Tools Used

Mathematics Self-efficacy Scale (MSES)

This Scale was developed by Usher and Pajares (2009) and adapted from the questionnaires of Betz & Hackett (1983) and Bandura (2006) to measure mathematical self-efficacy. It consists of 24 questions. Each question is rated on a 6-point Likert scale from 1 (completely incorrect) to 6 (completely correct), assessing students' beliefs about their ability in mathematics. The reliability of the questionnaire was reported as 0.93 using Cronbach's alpha. In Iran, the reliability of the questionnaire was also reported as 0.90 in the study by Kheir et al. (2012) and 0.87 in the study by Soltani Nezhad and Mahmoudi (2018). In this study, the Cronbach's alpha coefficient was 0.84. These findings indicate that the MSES is a reliable measure of mathematical self-efficacy over time.

Mathematical Resilience Scale

This questionnaire is an affective instrument that measures students' attitudes towards mathematics, which is assumed to be a predictor of positive responses to challenges in mathematics learning (Kooken et al., 2013). The scale consists of 24 items and was developed by Kooken et al. (2016) and has three dimensions: Value (8 items), struggle (9 items), and Growth (7 items). The score range for this scale is between 24 and 120. The response format for this scale is a 5-point Likert scale ranging from strongly disagree (1), disagree (2), no opinion (3), agree (4), and strongly agree (5). In the study by Kooken et al. (2013), the Cronbach's alpha coefficient was 0.94 for the Value dimension, 0.73 for the struggle dimension, and 0.83 for the Growth dimension. In the study by Gurefe & Akcakin (2018), the Cronbach's alpha coefficient for the total scale was 0.87 and for the Value, struggle, and Growth dimensions, respectively, were 0.92, 0.80, and 0.76. In the study by Aryanpour & Karimi (2021), which was the first time the questionnaire was used in Iran, the scale was administered in two different time periods and the Cronbach's alpha coefficient for the total scale was 0.81 and for the Value, struggle, and Growth subscales, respectively, were 0.86, 0.78, and 0.72. Additionally, the correlations between the Value, struggle, and Growth dimensions and the total scale were 0.71, 0.68, and 0.59, respectively. A significant relationship (r=0.66) was found between the scores of the questions on this scale in two different administrations in the assessment of retest reliability. The Cronbach's alpha coefficient for this questionnaire was also a satisfactory 0.81 in this study.

Mathematics Achievement

To measure students' mathematics achievement, the average of their final grades for the two previous semesters were used for a more accurate calculation of this variable.

Results

In the present study, which aimed to determine the mediating role of mathematical self-efficacy in the relationship between mathematical resilience and academic achievement in mathematics, a total of 282 students were examined. The research sample consisted of 138 girls (48.9%) and 144 boys (51.1%). The Table1 shows Descriptive statistics and correlations of the study variables.

Table 1 Descriptive statistics and correlation matrix of research variables

variable	M	SD	1	2	3
Math achievement	13/81	6/74	1		
Math self-efficacy	3/62	0/74	**0/265	1	
Math resilience	3/41	0/49	**0/271	**0/396	1

** P <۰/۰۱ * P <۰/۰۵

Before analyzing the data, the assumptions of normality and multicollinearity were examined. Chou and Bentler (1995) consider a kurtosis cut-off of ±3 to be appropriate. For the skewness, values greater than ±10 are generally problematic in structural equation modeling (Kline, 2011). The obtained values for kurtosis and skewness of the variables indicate that the assumption of normality is met.

To examine the assumption of multicollinearity, the variance inflation factor (VIF) and tolerance index were used. Since none of the tolerance index values are less than 0.10 and none of the VIF values are greater than 10, it can be concluded that the assumption of multicollinearity is also met.

As shown in Table 1, math resilience is significantly correlated with math self-efficacy and math achievement, with correlation coefficients of 0.27 and 0.40, respectively, both significant at the $p < 0.01$ level. Similarly, math self-efficacy is significantly correlated with math achievement, with a correlation coefficient of 0.26, also significant at the $p < 0.01$ level.

Path analysis was used to examine the direct and indirect effects of the variables. The results are presented in Figure 1 and the tables of direct and indirect effects.

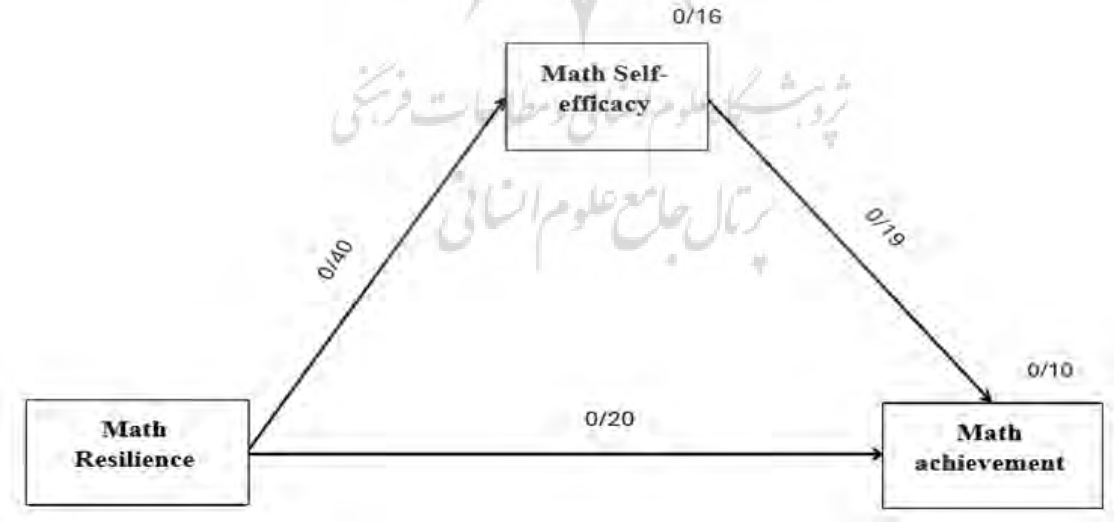

Figure 1 Standardized path coefficients of research variables in the main model

Figure 1 depicts meaningful paths as solid lines and non-meaningful paths as dashed lines. Based on the results presented in Figure 1, it can be observed that all paths are significant.
Furthermore, the results presented in Tables 2 and 3 demonstrate the direct and indirect effects of the research variables. These results can be utilized to confirm or refute the direct and indirect effects of the research variables on mathematical achievement.

Table 1 direct relationships of variables in the research model

Independent variable	Dependent variable	Unstandardized B	Standardized coefficients	Standard Error	T	P
Math Resilience	Math achievement	2/716	0/197	0/848	3/201	0/001
Math self-efficacy	Math achievement	1/703	0/187	0/561	3/035	0/002
Math Resilience	Math self-efficacy	0/599	0/396	0/083	7/232	0/001

According to Table 2, two variables are considered to have a significant relationship if the T-statistic falls outside the (-1.96, 1.96) range or if the significance level is less than 0.05. As can be seen, the direct path from mathematical resilience to mathematical achievement is significant (T=3.201, β=0.197). The direct path from mathematical self-efficacy to mathematical achievement is significant (T=3.035, β=0.187). The direct path from mathematical resilience to mathematical self-efficacy is significant (T=7.232, β=0.396).
Table 3 further reports the mediating effect of mathematical self-efficacy on the relationship between mathematical resilience and mathematical achievement using the bootstrap method with 2000 replications and a 95% confidence interval.

Table 2 Mediating effect of mathematical self-efficacy on the relationship between mathematical resilience and mathematical achievement

Independent variable	Mediator variable	Dependent variable	Non-standard Coefficient	Lower Bound	Upper Bound	P-value
Math Resilience	Math self-efficacy	Math achievement	1/02	0/335	2/357	0/001

According to Table 3, the indirect effect of mathematical resilience on mathematical achievement through mathematical self-efficacy is significant ($p<0.05$, b=1/02).

Discussion & Conclusion

The purpose of this study was to determine the mediating role of mathematical self-efficacy in the relationship between mathematical resilience and mathematics achievement. Mathematical resilience is a multifaceted construct that encompasses individuals' beliefs, attitudes, and motivations related to mathematics (Kooken et al., 2013). It represents a broader level of analysis than studies that examine the relationship between attitudes towards mathematics and other variables. The study of mathematical resilience is important because students with high mathematical resilience are motivated to respond positively to the challenges of learning mathematics, and this positive response is expected to lead to increased student attitudes towards mathematics and influence student achievement in mathematics, even in the face of difficulty and challenges (Kooken et al., 2015).
The results of this study indicated that mathematical resilience has a direct and significant effect on mathematical achievement. This finding is consistent with previous research (Johnston-Wilder & Lee,

2010; Vegara, 2021). This suggests that students in the humanities can achieve better results in mathematics if they have a positive attitude and approach to learning mathematics and make sufficient struggle to learn, especially when they face challenges and difficulties in learning mathematics. Due to their psychological resilience, these individuals perceive unpleasant events and difficulties as opportunities for learning and feel more control over their circumstances.

The results of this study also showed a positive and significant relationship between mathematical resilience and mathematical self-efficacy. This finding is consistent with previous research (Bron, 2022; Yager & Dweck, 2012; Mims, 2009). Given the concept of resilience, which refers to an individual's capacity to persevere in the face of difficulties and challenges, this allows the individual to overcome difficult situations and, as a result, enhances their sense of competence. Resilient learners believe in themselves and value learning, ultimately turning failure into an opportunity for growth (Babajani et al., 2019).

In examining the relationship between mathematical self-efficacy and mathematical achievement, it was found that mathematical self-efficacy has a direct and significant effect on mathematical achievement. This result is consistent with previous research in this area (Farahani & Karami, 2002; Madadpour et al., 2016), which supports Bandura's (1986, 1997) notion that self-efficacy beliefs predict academic outcomes.

In this study, mathematical self-efficacy significantly mediated the relationship between mathematical resilience and math achievement (Saeed, 2005). This means that mathematical resilience can explain changes in math achievement through mathematical self-efficacy. This finding is consistent with the findings of researchers (Superyva et al., 2022). Therefore, if students have a positive approach to learning math, that is, they value studying math for themselves and believe that they can make good achievement in this subject with effort, they will continue to learn math when faced with challenges and problems. They believe that they have the ability to overcome problems and can solve challenges with more effort, which will improve their performance in math.

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