Research Article

The Mediating Role of Mathematics Self-concept in the Association of Self-esteem and Classroom Environment Perceptions with Math Anxiety in Students

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Abstract

Background: Math anxiety (MA) emerges as a state of discomfort and anxiety when a student is faced with a math problem.

Objectives: The present study aimed to investigate the association between self-esteem and classroom environment perceptions with math anxiety through the mediating role of mathematics self-concept (MSC) in female high school students.

Methods: This descriptive-correlational study was conducted on all the female high school students in Ahvaz, Iran in the academic year 2020 - 2021. In total, 237 students were selected as the sample population via single-stage cluster sampling. Data were collected using the Math Anxiety questionnaire (MAQ), Self-esteem questionnaire (SEQ), Dundee Ready Educational Environment measure (DREEM), and Mathematical Self-concept questionnaire (MSCQ). The proposed research model was evaluated using structural equation modeling.

Results: With the exception of self-esteem and classroom environment perceptions (CEPs), all the direct paths were significantly correlated with MA (P = 0.001). Moreover, the indirect paths of self-esteem were significantly correlated with MA considering the mediating role of MSC (β = -0.240; P = 0.002). Furthermore, a significant association was observed between CEP and MA, mediated by MSC (β = -0.129; P = 0.001).

Conclusions: According to the results, the proposed model had a good fit and could be an important step in identifying the influential factors in the MA of students.

Keywords: Anxiety, Perceptions, Self-esteem, Self-concept, Students

1. Background

Students keep coming up with the question of why they study mathematics, and there are no compelling short answers in this regard (1). Recent evidence attests to an educational failure in mathematics at different levels of education since students fail to comprehend math and rarely become interested in the subject (2). Students often have difficulty learning match and cannot develop a sincere and appropriate relationship with math teachers (3). Consequently, they tend to experience match anxiety (MA), which may undermine their performance in mathematics.

MA emerges as a state of discomfort and anxiety when a student is faced with a math problem (4). According to Choi-Koh and Ryoo (5), MA is a psychological state that occurs when the individual is confronted with a mathematical content whether in a teaching/learning situation or while solving mathematical problems and measuring

mathematical behavior. MA is often accompanied by extreme anxiety, mental disorders, obsessive-compulsive disorder, psychological stress, and the subsequent stagnation of thoughts. Some mathematicians believe that MA is rooted in the early years of elementary school (6).

The emergence of MA may be attributed to several factors, including poor self-concept, poor skills, school refusal, teachers' attitude, and emphasis on teaching math through traditional methods and math comprehension through excessive practice and homework (7). The present study aimed to assess the impact of psychological and environmental factors on MA. Self-esteem is considered to be a significant influential factor in this regard. Self-esteem is a psychological construct that has drawn the attention of numerous psychologists and researchers in recent decades. In general, the self-evaluations of an individual shape their self-esteem (8). Self-esteem may be defined as the degree to which individuals approve of, ac-

cept, and value themselves ([9]). According to Harris et al. ([10]), self-esteem is attained in interpersonal relationships and is a reflection of others' views toward a person, which determines the way an individual deals with different issues. Self-esteem also shows one's self-worth as an individual ([11]). Rajabi et al. ([12]) stated that self-esteem and context-independent cognitive style have a significant, negative association with the MA of female students. In addition, Xai et al. ([13]) reported a significant, negative association between self-esteem and MA, as well as a significant, positive association between test anxiety and MA in male and female students.

Classroom environment perception (CEP) is another influential factor in test anxiety ([14]) In recent decades, research has shown that the quality of the learning environment plays a pivotal role in learning, and students have a positive performance and attitude toward educational contents if they have a positive perception of the learning environment ([15]). The learning environment is a setting where learners and teachers interact and exploit various tools and information resources to pursue learning activities ([16]). However, the psychological environment of the classroom, environmental/social characteristics, and teacher's support significantly affect learners' behaviors, purpose, self-belief, strategies, educational/social motivation, homework engagement, educational value, and educational achievement ([17]). In this regard, Sharifi Saki et al. ([18]) stated that self-efficacy and self-concept play a mediating role between CEP and educational achievement. Moreover, Zaki ([19]) observed that math test anxiety has a significant, negative association with classroom goal structures. Deieso and Fraser ([20]) also reported that students' perception of the learning environment and their math attitude have a significant, negative association with their MA.

Self-esteem and CEP are directly correlated with MA, while they indirectly affect students' MA through the influence of mathematics self-concept (MSC). Self-concept refers to the recognition and perception of individuals toward their personal traits ([21]). In other words, a person's behaviors in different contexts indicate their knowledge and acceptance of themselves ([22]). Self-concept is a psychological trait that refers to an individual's belief in their abilities and talents to successfully perform activities toward their goals. Educational self-concept refers to the realistic attitudes of students toward educational self-efficacy based on their educational identity ([23]). Evidence suggests that students' self-concept improves their educational performance ([24], [25]). MSC shows learners' perception of their ability to learn mathematics and do the related homework ([26]). Various studies have confirmed that MSC plays a key role in reducing students' MA ([27], [28]).

The increasing level of MA among students and its con-

tinuation until university admission necessitate adequate research in this regard in order to develop proper math attitudes and self-concept in students, thereby overcoming MA. Numerous students have math phobia and anxiety and resist learning math for different reasons, such as teachers' teaching styles, experience of failure, parental pressures, lack of practice, and difficulty learning math concepts, which cause failure in solving even the simplest of math problems ([29]). However, the current use of mathematics in new sciences and technologies necessitates proper math learning and comprehending the rules of this subject ([30]).

2. Objectives

With this background, the present study aimed to investigate the association between self-esteem and CEPs with MA through the mediating role of MSC in female high school students in Ahvaz, Iran.

3. Methods

This descriptive-correlational study was conducted by using structural equations and single-stage cluster sampling. Out of the four districts of Ahvaz, District 4 was randomly selected, and from among the girls' high schools in this district, seven schools were randomly selected. Attending the selected schools and coordinating with the students' parents, the researchers randomly selected three classrooms. Due to the COVID-19 pandemic and the current online classes, they presented the teachers with a questionnaire links to be shared with the WhatsApp class groups.

In total, 260 female students of experimental sciences in the 10th grade (n = 85), 11th grade (n = 78), and 12th grade (n = 97) completed the questionnaire. After excluding 23 incomplete questionnaires, the researchers selected 237 students, who had properly completed the questionnaire, as the sample population of the study. The inclusion criteria were consent to participate, age of 16 - 18 years, and no mental disorders. The exclusion criteria were failure to complete the questionnaire. Information confidentiality, willingness to participate in the research, and observance of participants' rights were the ethical considerations of the study.

3.1. Research Instruments

3.1.1. Math Anxiety Questionnaire

The Math Anxiety questionnaire (MAQ) was developed by Plake and Parker ([31]) in 1982 to assess the anxiety associated with attendance in high school math and statistics

classes. This version places more emphasis on the anxiety evoked by specific situations (i.e., state anxiety), generalized anxiety (i.e., trait anxiety), and test anxiety. MAQ consists of 24 items that measure the level of anxiety in the mathematics and statistics assessment position. This tool is considered appropriate for high school and university students. Respondents indicate their degree of agreement/disagreement with each questionnaire item based on a five-point Likert scale, with scores one, two, three, four, and five interpreted as low anxiety, partial anxiety, moderate anxiety, high anxiety, and extremely high anxiety. The total MA score of the subjects was calculated from the sum of the scores of all the items. The minimum and maximum obtainable scores on the checklist were 24 and 120, respectively. Higher scores indicated the higher level of MA, and the total score of the test was considered for this purpose ([31]). In Iran, Ghadampour et al. ([27]) have reported the Cronbach's alpha of 0.88 for the questionnaire, while the Cronbach's alpha coefficient was determined to be 0.87 in our study.

3.1.2. Self-esteem Questionnaire

The Self-esteem questionnaire (SEQ) was developed by Cooper Smith in 1990 to measure self-feedback in the social, family, school, and personal domains, with an add-on lie scale. The SEQ consists of 58 items that describe feelings, opinions, and reactions. Each subject should respond to the items by marking four boxes pertaining to the subjects of similar to me (yes) or not similar to me (no) with the scores one and zero, respectively. The other items in the SEQ are scored in a reverse manner. Najafi et al. ([32]) have reported the Cronbach's alpha of 0.87 for the questionnaire, and the Cronbach's alpha coefficient was estimated at 0.84 in our study.

3.1.3. Dundee Ready Education Environment Measure

Dundee Ready Education Environment measure (DREEM) was designed by Dundee in 2001 with 49 items to measure educational quality in different dimensions, including students' perception of learning, students' perception of their teacher, students' perception of their scientific ability, students' perception of the educational environment, and students' perception of their social status. The items are scored based on a five-point Likert scale (very low: 1, low: 2, medium: 3, high: 4, very high: 5). The maximum score of this scale is 245. The score range of 0-50 shows a very poor environment, score range of 51 - 100 shows a problematic/unfavorable environment, score range of 101 - 150 is interpreted as a more positive attitude, and the score range of 151 - 245 indicates an excellent environment. Bahrami et al. ([33]) reported the

Cronbach's alpha of 0.84 for DREEM, and the Cronbach's alpha coefficient was estimated at 0.80 in our study.

3.1.4. Mathematical Self-concept Questionnaire

Mathematical Self-concept questionnaire (MSCQ) was developed by Marsh in 2004 and extracted using the analysis of the factors related to math. MSCQ consists of 12 items to be answered by students based on a five-point Likert scale (strongly agree: 5, strongly disagree: 1). Saleh Sedghpour and Ebrahim Damavandi ([34]) examined the factor structure of this scale, reporting two subscales of 'interest in mathematics' (seven items) and 'perception of mathematical ability' (five items) with acceptable construct validity (GFI: 0.97, AGFI: 0.90). In addition, Ghadampour et al. ([27]) reported the Cronbach's alpha coefficient of 0.83 for the questionnaire, and the Cronbach's alpha coefficient was estimated at 0.80 in our study.

3.2. Statistical Analysis

Data analysis was performed in SPSS version 25 and AMOS version 24 using descriptive statistics (mean and standard deviation) Pearson's correlation-coefficient, and structural equations.

4. Results

In total, 237 female high school students were enrolled in the study, with the mean age of 16.21 ± 1.87 years. Table 1 shows the results of Pearson's correlation-coefficient and descriptive statistics, including the mean values of the research variables. Figure 1 depicts the initially proposed model to clarify MA based on MSC, self-esteem, and CEP.

According to the information in Table 2, the root mean square error of approximation (RMSEA = 0.394) indicated that the initial model required modification. As the initial model was the saturated model plotting all the possible paths, it was impossible to calculate the chi-square and other indicators. After eliminating two paths (self-concept to MA and CEP), the model was desaturated, and we could calculate the chi-square and other indicators of the software. In the final model, the RMSEA was estimated at 0.001, indicating the good fit of the model. The modified model is shown in Figure 2.

Our findings indicated a direct association between self-esteem and MSCs (β = 0.240; P = 0.001), as well as CEPs and MSC in the female high school students (β = 0.426; P = 0.001). On the other hand, a negative association was observed between MSC and MA in the female high school students (β = -0.557; P = 0.001), while no significant association was denoted between self-esteem and MA, as well as CEPs and MA, in the female high school students (Table 3).

Table 1. Mean Values and Pearson's Correlation Coefficients of Research Variables

Variables	Mean ± SD	1	2	3	4
1. Math anxiety (MA)	69.22 ± 28.41	1			
2. Self-esteem	32.57 ± 15.85	-0.286	1		
3. Classroom environment perceptions (CEPs)	158.36 ± 52.07	-0.287	0.308	1	
4. Mathematics self-concept (MSC)	29.09 ± 11.41	-0.557	0.289	0.321	1
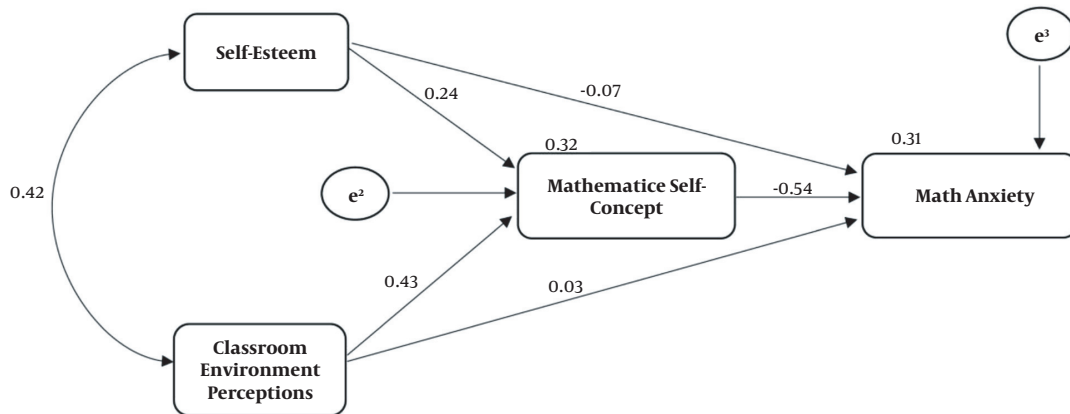
Figure 1. Initial model pertaining to mediating role of MSC in association between self-esteem and CEPs with MA

Table 2. Fit Indicators of Initial and Final Models

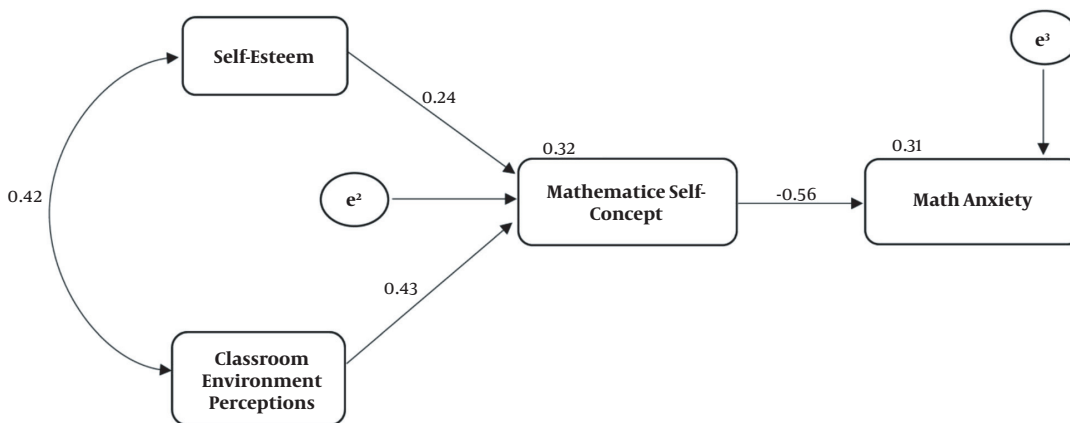| Fit Indicators	χ^2	df	(χ^2/df)	IFI	TLI	CFI	NFI	RMSEA
Initial model	-	-	-	-	0.860	0.890	-	0.394
Final model	1.380	2	0.69	1.00	1.00	1.00	0.990	0.001

Figure 2. Final model pertaining to mediating role of MSC in association between self-esteem and CEPs with MA

The obtained results indicated a significant, indirect path from self-esteem to MA through the mediating role of MSC in the female high school students (β = -0.240; P = 0.002). Moreover, the indirect path from CEPs to MA was considered significant through the mediating role of MSC (β = -0.129; P = 0.001) (Table 4).

Table 3. Direct Effects Between Research Variables in Final Modified Model

Path	Final Modified Model	
	β	P
Self-esteem to MA	-	-
Self-esteem to MSC	0.240	0.001
CEPs to MA	-	-
CEPs to MSC	0.426	0.001
MSC to MA	-0.557	0.001

5. Discussion

The present study aimed to investigate the association between self-esteem and CEPs with MA through the mediating role of MSC in the female high school students in Ahvaz. The obtained results showed that except the paths of self-esteem and CEP, all the direct paths were significantly correlated with MA. In addition, the indirect paths were significantly correlated to this variable through MSC.

The first finding of our study indicated no significant association between self-esteem and MA, which is inconsistent with the results obtained by Xie et al. (13). In the mentioned study, the association between self-esteem and MA was evaluated using correlation-coefficient and regression tests and considered significant. In the present study, the hypotheses were tested by using modeling structural equations. Initially, the association between self-esteem and MA was considered significant based on Pearson's correlation-coefficient, while with a mediating variable in the model, the effect of self-esteem on MA could be entirely explained through the same variable (indirect association). In other words, self-esteem indirectly affected MA in the proposed model. In general, a society where the members enjoy higher self-esteem is resistant to life problems, psychological stresses, natural threats/disasters, and mental disorders, which nurtures talents and creativity and results in cultural, economic, and social development (12). However, the hypothesis of the current research indicated that another important factor (i.e., MSC) could thoroughly explain the association between self-esteem and MA and render the direct association between these variables insignificant.

The findings of the current research indicated no significant association between CEP and MA, which is inconsistent with the results obtained by Sharifi Saki et al. (18) and Deieso and Fraser (20). In the mentioned studies, the association between these variables was assessed using correlation-coefficient and regression tests and reported to be significant. In our study, the hypotheses were tested using modeling structural equations. Initially, the association between CEP and MA proved significant based on Pear-

son's correlation-coefficient, while with a mediating variable in the model, the effect of CEP on MA could thoroughly explain the same variable (indirect association). In other words, CEP indirectly affected MA in the proposed model. The hypothesis in the present study demonstrated that another important factor (i.e., MSC) could entirely explain the association between CEP and MA and render the direct association between these variables insignificant.

Another finding of the present study showed a direct, negative association between the students' MSC and MA, and their improved MSC was expected to decrease their MA level. This is consistent with the results obtained Ghadampour et al. (27) and Aligholipoor et al. (28). In general, MSC shows the beliefs/perceptions of one's ability to solve a math problem, which helps with the efficient solving of the math problem (35). Individuals with high self-efficacy oversee the thought and regulation of their individuals, control commitments and problems, and engage in more threatening and challenging situations. They also see problems as challenges rather than threats and actively seek new opportunities (22). Furthermore, those with high MSC can engage in more challenging matters. Through curiosity, they seek appropriate solutions to their problems and show more perseverance in solving their educational problems; as a result, they experience less MA (36). A significant association has been reported between mathematics self-efficacy (MSE) and the use of cognitive strategies. Therefore, it could be concluded that promoting self-efficacy and self-concept beliefs increase the use of cognitive strategies, thereby enhancing performance and reducing MA (37). MSE and MSC beliefs prove effective through insistence on doing homework, using cognitive and metacognitive strategies, self-organization, and perseverance in the face of difficulties.

According to the results of the present study, MSC mediated the association of self-esteem and CEP with MA. A literature review in this regard showed that no studies have been focused on the same subjects, and our findings cannot be compared. In the direct path, the obtained results indicated no significant association between self-esteem and MA. On the other hand, the indirect hypothesis showed an association between self-esteem and MA only when the students' self-esteem was associated with an increase in their MSC, so that MA could be decreased. However, the second hypothesis indicated no significant association between CEP and MA, while the indirect hypothesis showed an association between CEP and MA only when the students' self-esteem was associated with an increase in their MSC, so that MA could be decreased. These findings highlight the correct choice of the mediating variable in the present study.

In the current research, the mediation of the MSC vari-

Table 4. Analysis of Indirect and Intermediary Paths in Final Modified Model

Predictive Variable	Mediating Variable	Criterion Variable	Final Modified Model	
			Bootstrap	P-Value
Self-esteem	MSC	MA	-0.240	0.002
CEPs	MSC	MA	-0.129	0.001

able led to the failure of the direct effect of self-esteem and CEP. In general, MA could undermine students' performance in mathematics. MA emerges as a state of discomfort and anxiety when a student is faced with a math problem (4). This state is characterized by feelings of dislike, concern, and fear, as well as specific behavioral manifestations such as tension, frustration, distress, disability, confusion, panic, embarrassment, inability to cope, palm sweat, and stomach, breathing, and concentration problems. According to Putwain et al. (38), high performance in mathematics is associated with low anxiety, and low academic vitality is associated with high anxiety.

The main limitation of our study was the use of self-report tools as the accuracy of the responses might have been affected by the subjects' social desirability bias. Moreover, as the sample population was limited to female high school students in Ahvaz, the generalization of the findings to the male and female students of other educational levels in other areas should be with caution. It is suggested that similar studies be conducted on male students as well for comparative purposes.

5.1. Conclusions

According to the results, the proposed model had an acceptable fit and could be considered an important step toward identifying the key influential factors in students' MA. Given that the proposed conceptual model had a good fit, it could be regarded as a new innovation and scientific finding that proves effective in preventing educational failure and MA. By studying and realizing the importance of the subject, students' parents and teachers could use the model to prevent educational failure, educational demotivation, and negative attitudes toward mathematics. Furthermore, holding in-service workshops by experienced teachers in the field of mathematics could familiarize teachers with interesting methods of teaching mathematics, while also improving students' MSC and reducing their MA level.

Footnotes

Authors' Contribution: Maasomeh Naderi Dehsheykh did study concept and design, acquisition of data, analysis and interpretation of data, and statistical analysis. Fariba

Hafezi did administrative, technical, and material support, and study supervision. Fariba Hafezi and Zahra Dasht Bozorgi did critical revision of the manuscript for important intellectual content.

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