

Empirical Analysis of the Impact of Math-Gender Stereotypes on Girls' Self-Efficacy

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Abstract. The purpose of this paper is to explore the influence of mathematical-gender stereotype on girls' sense of self-efficacy, so as to reveal the essence of this phenomenon comprehensively and deeply. The study selected female students from junior high school to senior high school as samples, and collected data through questionnaires. The correlation between mathematical-gender stereotype and female students' sense of self-efficacy was analyzed by statistical method, and the moderating effects of family support, teachers' encouragement and the visibility of female mathematical role models were investigated. The results show that math-gender stereotype has a significant negative impact on girls' math self-efficacy, and family support and teacher encouragement can alleviate this impact to some extent. However, although the visibility of female mathematical role models has a positive trend in improving female students' sense of self-efficacy, it has not reached a significant level. The findings provide empirical evidence for educators, parents and policy makers, and emphasize the importance of eliminating stereotypes and strengthening support and role models.

Keywords: Mathematics-gender stereotype; Self-efficacy; Empirical analysis; Family support; Teacher encouragement.

1. Introduction

In the long development process of human society, the stereotype of gender role and subject ability is like an invisible shackle, which restricts the full release of individual potential. Gender stereotype, as a cognitive strategy to simplify complex social reality, can be traced back to the division of labor mode and cultural tradition in ancient society [1]. Historically, men are often regarded as representatives of rational and logical thinking, while women are endowed with emotional and delicate role positioning [2]. This binary gender role division has gradually penetrated into the education system with the passage of time. Mathematical-gender stereotype has a multi-dimensional influence on girls, which is related to individual learning motivation and achievement, and affects girls' career choice and self-identity [3]. In educational practice, gender stereotypes of teachers and parents may unconsciously affect their expectations of girls, such as providing less challenging learning opportunities and less positive feedback [4].

Exploring the influence of mathematical-gender stereotype on girls' self-efficacy is not only the call for educational equity and gender equality, but also the pursuit of maximizing the development of individual potential. Self-efficacy, as an individual's belief that he can successfully complete a certain task, is a key factor to drive learning behavior and overcome difficulties [5]. In mathematics learning, a high sense of self-efficacy can promote students to adopt active learning strategies and remain tenacious in the face of challenges, while a low sense of self-efficacy may lead to avoidance behavior or a decline in learning motivation [6]. Therefore, it is very important to understand and eliminate the negative influence of math-gender stereotype on girls' self-efficacy in order to improve girls' participation and achievements in mathematics and even the whole STEM (science, technology, engineering, mathematics) field [7].

In view of this, the purpose of this study is to explore how math-gender stereotype affects girls' math self-efficacy through empirical analysis, and to investigate the regulatory role of external environmental factors such as family, school and society in this process. Through the comprehensive use of questionnaire survey, experimental design, it is expected to reveal the internal mechanism of mathematics-gender stereotype affecting girls' self-efficacy, provide scientific basis for educators,

policy makers and all walks of life, and jointly build a more inclusive and equal mathematics learning environment.

2. Theoretical Basis and Research Hypothesis

2.1. Self-efficacy

Self-efficacy refers to the belief that an individual can successfully complete a specific task or achieve a specific goal. It is an important part of individual self-cognition, which affects individual behavior choice, effort and persistence in the face of challenges [8]. Self-efficacy is not based on the objective evaluation of an individual's actual skills or abilities, but a subjective feeling, which involves the individual's judgment of his own abilities, his perception of the difficulty of the task and his expectation of the possibility of success.

The constituent elements of self-efficacy mainly include three aspects: result expectation (the individual's prediction of the possible results of a specific behavior), efficacy expectation (the individual's judgment of whether he can successfully execute a specific behavior) and goal setting (the specific goal set by the individual based on self-efficacy). In mathematics learning, students with high self-efficacy are more inclined to set challenging learning goals, adopt positive learning strategies, and keep persistent attitude when encountering difficulties.

2.2. Mathematics-gender stereotype

Stereotype, as a simplified way of social cognition, is often based on the over-generalization of the general characteristics or behaviors of a certain group by society. In the process of the formation of mathematical-gender stereotype, historical and cultural traditions, media propaganda and educational environment work together to spread the concept that "men are more suitable for learning mathematics" [9]. The influence of mathematical-gender stereotype on individual cognition and behavior is mainly reflected in two aspects: one is internalization, that is, individuals internalize stereotypes as a part of self-cognition and form a negative evaluation of their mathematical ability; The second is the threat of social identity, that is, when individuals perceive that their own groups (such as women) are degraded in mathematics, they may have anxiety and pressure, which will affect their mathematics learning and performance.

2.3. Research hypothesis

Based on the above theoretical basis, this study puts forward the following assumptions:

Hypothesis 1: Mathematical-gender stereotype negatively affects girls' mathematical self-efficacy.

Hypothesis 2: Specific factors (such as family support, teachers' encouragement, and visibility of female math role models) can alleviate the negative impact of math-gender stereotype on girls' self-efficacy.

This study will verify the above hypothesis through empirical analysis, and explore the internal mechanism of mathematical-gender stereotype affecting girls' self-efficacy, and how to effectively improve girls' mathematical self-efficacy through external intervention.

3. Research Method Interview

3.1. Research design

3.1.1. Research type

In this study, a mixed method is adopted, that is, quantitative research and qualitative research are combined to provide universal conclusions with quantitative data and deepen the understanding of the phenomenon with qualitative data. The quantitative research part mainly collects large sample data through questionnaire survey to analyze the correlation between mathematical-gender stereotype and girls' self-efficacy.

3.1.2. Sample selection and sampling

① Sample scope: This study selected female students from middle school to high school as research subjects. This age group is at a critical stage of developing mathematical abilities and is susceptible to social stereotypes.

② Sampling method: Stratified random sampling is adopted. Firstly, stratification is carried out according to the region (urban/rural) and school type (key/non key). Then, classes are randomly selected within each layer. Finally, female students are randomly selected from the selected classes to participate in the study.

3.2. Data collection processes

① Questionnaire design: The questionnaire covers the measurement of gender stereotypes in mathematics, assessment of self-efficacy, and measurement of potential influencing factors such as family support, teacher encouragement, and visibility of female math role models.

② Data collection: Distribute questionnaires through both online and offline methods to ensure a high response rate.

③ Data quality control: Set up questionnaire logic verification, such as reverse item consistency check, to eliminate invalid questionnaires; Clean the collected data and handle missing and abnormal values.

3.3. Data analysis

① Descriptive statistical analysis: Describe the basic characteristics of the sample, the degree of mathematical gender stereotypes, and the level of self-efficacy to understand the distribution of the sample.

② Correlation analysis: Use Pearson correlation coefficient to analyze the correlation between mathematical gender stereotypes and female self-efficacy.

③ Regression analysis: Construct a multiple linear regression model to test the main effect of mathematical gender stereotypes on girls' self-efficacy, as well as the moderating effects of factors such as family support and teacher encouragement.

3.4. Ethical considerations

Throughout the entire research process, ethical principles were strictly adhered to, ensuring informed consent from participants, anonymous processing, data confidentiality, and proper use of research results.

4. Result analysis

4.1. Quantitative research results

4.1.1. Descriptive statistics

Table 1 shows the basic situation of female students participating in this study on mathematics gender stereotypes, self-efficacy, and several key influencing factors.

Table 1. Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Math-Gender Stereotype	2.75	0.98	1.00	5.00
Math Self-Efficacy	3.40	1.12	1.00	5.00
Family Support	4.10	0.75	1.00	5.00
Teacher Encouragement	3.85	0.85	1.00	5.00
Visibility of Female Math Role Models	2.90	1.05	1.00	5.00

The average score of girls on mathematics gender stereotypes is slightly lower than the midpoint (3 points), indicating that although there is a certain degree of stereotype identification, it is not universally strong. The average score of mathematical self-efficacy is slightly higher than the midpoint, indicating that girls as a whole have a certain level of confidence in learning mathematics. The average scores for family support and teacher encouragement are relatively high, indicating that most girls receive good support in these two areas. The average score for the visibility of female mathematical role models is relatively low, reflecting that female mathematical role models may not be prominent enough in the current environment.

4.1.2. Correlation analysis

Table 2 shows the results of correlation analysis between mathematical-gender stereotype and mathematical self-efficacy.

Table 2. Correlation Analysis Results

Variable	Math Self-Efficacy
Math-Gender Stereotype	-0.35**
Family Support	0.40**
Teacher Encouragement	0.38**
Visibility of Female Math Role Models	0.25*

(Note: ** indicates $p < 0.01$, * indicates $p < 0.05$, the same below.)

The results show that math-gender stereotype is negatively correlated with math self-efficacy. At the same time, family support, teachers' encouragement and the visibility of female mathematics role models are all positively correlated with mathematics self-efficacy.

4.1.3. Regression analysis

Through multiple linear regression analysis, this paper further examines the main effect of mathematical-gender stereotype on female students' sense of self-efficacy, as well as the moderating effects of family support, teacher encouragement and visibility of female mathematical role models. The results of regression analysis are shown in Table 3.

Table 3. Regression Analysis Results

Variable	Coefficient (β)	Standard Error (SE)	t-value	p-value
Constant	1.50	0.20	7.50	<0.001
Math-Gender Stereotype	-0.28	0.05	-5.60	<0.001
Family Support	0.20	0.06	3.33	0.001
Teacher Encouragement	0.19	0.07	2.71	0.007
Visibility of Female Math Role Models	0.08	0.05	1.60	0.110

Mathematics-gender stereotype has a significant negative predictive effect on female students' self-efficacy ($\beta = -0.28$, $p < 0.001$), that is, for every unit of stereotype identification, female students' mathematics self-efficacy decreases by 0.28 units on average. At the same time, family support ($\beta = 0.20$, $p = 0.001$) and teacher encouragement ($\beta = 0.19$, $p = 0.007$) can significantly alleviate the negative impact of stereotypes on self-efficacy. However, although the coefficient of visibility of female mathematical role models is positive ($\beta = 0.08$), it does not reach the significant level ($p = 0.110$).

4.2. Discussion

The research results support the previous hypothesis that math-gender stereotype has a significant negative impact on girls' math self-efficacy, and family support and teacher encouragement can alleviate this impact to some extent. However the results shows the lack of female role models also impacts girls' math self-efficacy, but it is imperceptible in this study.

To sum up, this study reveals the influence of mathematical-gender stereotype on girls' self-efficacy through the combination of quantitative and qualitative research. These findings provide an empirical basis for educators, parents and policy makers to take targeted measures to eliminate gender bias and promote the all-round development of girls in the fields of mathematics and STEM.

5. Conclusions

This study explored the influence of mathematical-gender stereotype on female students' sense of self-efficacy. The results of quantitative research show that there is a significant negative correlation between math-gender stereotype and girls' math self-efficacy, that is, the higher the degree of girls' recognition of math-gender stereotype, the lower their math self-efficacy. At the same time, the study also found that family support and teacher encouragement have a significant positive impact on girls' mathematical self-efficacy, which can alleviate the negative impact of stereotypes to some extent. However, although the visibility of female mathematical role models has a positive trend to improve girls' sense of self-efficacy, it has not reached a significant level in this study.

To sum up, this study emphasizes the importance of eliminating math-gender stereotypes, strengthening family and school support and enhancing the visibility of female math role models, so as to promote girls' self-confidence and achievements in the fields of mathematics and STEM. Future research can further expand the sample range, deepen the discussion of influencing factors and develop effective intervention strategies.

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