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The Influence of mathematical meta-emotions on the Perceived Value of Mathematical Tasks Among Secondary School Students: The Moderating Role of Peer Relationships

Shengru Huang *

Department of Education, Sichuan Normal University, University Address: No. 5 Jing'an Road, Jinjiang District, Chengdu, Sichuan, 610066, China

*** Corresponding author Email:** 1811263698@qq.com

Abstract: In response to the widespread issue of maths anxiety among secondary school students today, this study focuses on the variable of meta-emotions towards mathematics. It explores how students' ability to monitor and regulate their emotions towards maths learning influences their perceived value of maths tasks, and examines the moderating role of peer relationships in this context. This study employed convenience sampling to select 294 junior secondary school students from a secondary school in Chengdu as the study sample. A questionnaire survey method was used, with data collected via three revised scales, and statistical analysis was conducted using SPSS and the PROCESS macro. The results indicate that meta-emotions towards mathematics positively predict task value ($r = 0.698$, $\beta = 0.503$, $p < 0.001$), with significant positive correlations between all three variables in every pair; the interaction term between meta-emotions towards mathematics and peer relationships showed no significant moderating effect ($\beta = 0.097$, $p = 0.082$), with high levels of peer relationships only slightly increasing the prediction slope. The findings suggest that enhancing mathematical meta-affect can effectively strengthen students' sense of the value of mathematical tasks, whilst the moderating effect of peer relationships is not significant; future research may explore additional moderating variables.

Keywords: Mathematical Meta-emotions; Perceived Value of Mathematical Tasks; Peer Relationships; Moderating Effect; Junior High School Students.

1. Introduction

1.1. Problem Statement

The 'Compulsory Education Mathematics Curriculum Standards (2022 Edition)' emphasise that mathematics learning should focus on students' emotional experiences; however, approximately 40.9% of Year 8 students in China experience moderate to high levels of mathematics anxiety [1]. How to effectively regulate students' emotional experiences in mathematics education has become an urgent issue requiring resolution.

To address this challenge, researchers have increasingly turned their attention to 'meta-emotions', that is, the ability to monitor and regulate one's own emotions [2]. Unlike traditional research on mathematical anxiety and interest, meta-emotions emphasise an individual's ability to recognise and regulate their emotions. Existing research indicates that positive meta-emotions can help students overcome fear and tackle difficulties proactively [3].

According to the expectancy-value theory, students' perceived value of a task determines their academic engagement [4]. The value of a maths task refers to students' overall perception of its enjoyment, importance and usefulness [5]. A relatively large capacity for self-regulation of negative emotions at the meta-level in students may increase their willingness to engage in learning mathematical tasks. In other words, at a higher level, this indicates that meta-emotions in the area of mathematics may be a suitable precursor to the sense of task value. However, the learning environment is not socially neutral, and peer relationships also affect the all-round development of young people [6]. Given the specific circumstances of mathematics learning, it can be assumed that the peer environment may not only serve as an external background but also act as a boundary condition to enhance, reduce or change the association between meta-emotional regulation and subjective task valuation.

In light of the above, this paper aims to investigate how mathematical meta-emotions affect secondary school students' evaluations of mathematical tasks and whether peer relationships modify this process; at the end, this may offer some support for teaching practice.

1.2. Literature Review

Mathematical meta-emotions are high-level cognitive systems that help learners observe, judge and choose how they want to feel about learning mathematics. Rather than concentrating on the valence and intensity of emotions, the regulatory dimension of this construct refers to one's own conscious regulation of emotions through cognition. Thus, it is a change in concept from emotion-as-outcome to emotion-as-process in mathematics education research [7]. Goldin provided a typical case: when learners reconstruct mathematical concepts, the strong emotions that arise can be viewed as an instance of a situation where meta-emotions occur; that is, recognising and regulating one's own affective responses [8]. Although there is no direct empirical evidence of the link between mathematical meta-emotions and task value, a well-known line of research has shown that an optimistic attitude towards emotional regulation can strengthen intrinsic motivation to learn. Based on the general

motivational theory mentioned above, this study can be framed within this theory [9].

Task value generally refers to students' sense of the purpose of learning, which includes interest in the learning content, relevance to their lives, etc [10], aand can also predict a student's academic performance well. As Wigfield and Eccles [11] have shown, the academic performance of students is generally higher when they feel that mathematics has real-life applications and are motivated by the pleasure of solving problems. Zhang Xiaogui [12] believes that a positive perception of task value promotes the development of a positive mathematical self-concept in students. A well-documented association links perceived task value to students' academic engagement and outcomes, yet the role of affective processes—particularly meta-emotional ones—in shaping such perceptions has received limited attention. The moderating influence of peer relationships in this dynamic remains, to our knowledge, an open question.

Peer relationships—stable ties among same-age individuals—emerge through ongoing interaction [13]. Of the three core social systems—parent-child, teacher-student, and peer—the peer group is especially important for adolescents' emotional well-being. The reason lies in the age and cognitive commonality among peers [14]. Students with strong peer support show greater psychological resilience in emotional and social adjustment [15]. While prior research has linked peer quality mainly to academic achievement, the emotionally charged nature of mathematical problem-solving raises the possibility that peer climate could also affect students' task interest and value perception.

This study therefore positions peer relationships as a moderating factor in the meta-emotion–task value link. The analysis of this moderating mechanism serves both theoretical and pedagogical purposes.

1.3. Hypotheses Development

Based on the preceding discussion, we propose two core hypotheses. First, mathematical meta-emotions are positively associated with the perceived value of mathematical tasks. Second, peer relationships mediate this association. The proposed model is as follows: Figure 1.

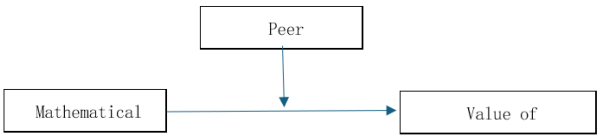

Figure 1. Moderating Role of Peer Relationships in the Link Between Mathematical Meta-Emotion and Task Value

2. Research Methods

2.1. Participants

Convenience sampling was employed to recruit 294 valid participants (89.09% of the 330 distributed) from Years 7-9 at a Chengdu secondary school. The sample included 85 Year 7, 137 Year 8 and 72 Year 9 students; 162 male and 132 female.

2.2. Research Instruments

2.2.1. Mathematics Meta-Emotion Scale

Zhang Guofeng adapted Zhang Sheng's questionnaire to measure students' mathematical meta-emotions, originally intended for lower secondary school students [7]. The first 38 items were in a five-point scale initially. Based on the initial data analysis, 20 items were selected for the formal assessment, and the revised instrument showed good internal consistency with a Cronbach's α of 0.948.

2.2.2. Mathematical Task Value Scale

Qi Yue created a device for measuring the level of the task. This instrument is based on Expectancy-Value Theory and other studies of task value. [16] First, we found five attributes in the original scale: intrinsic interest, utility, external motivators, altruism and effort investment, and then reduced them to seven items. The new measure had a Cronbach's α of 0.844 and was therefore reliable.

2.2.3. Peer Relationship Scale

Guo Bolian developed a scale for measuring peer relationships in children and adolescents, which is used in this study [17]. The previous studies have used this indicator on young people. There is a total of 22 four-point Likert items, some of which are reverse-scored; a higher total score indicates worse peer relationships, and a lower score indicates a more positive peer environment. Nine items were excluded in the scale refinement, and reliability analysis was conducted on the rest. The shortened version had a Cronbach's α of 0.813 and thus met the lower bound for empirical studies.

2.3. Research Procedure

Permission for the study was obtained from the school's administration and the teachers of the subjects before collecting data. Students were fully informed about the purpose and content of the study, and then they provided written consent. Then, in the class, I distributed the completed questionnaires to the students and collected them at the same time.

2.4. Data Processing

We processed and analyzed the data using SPSS, focusing on four key areas.

We ran descriptive statistics on the three questionnaire scores to establish the overall levels and distributional properties of each variable.

We first examined gender differences in the three variables using an independent samples t-test. A one-way ANOVA was then performed to compare year-level differences across the same set of variables.

Third, correlation analysis. Pearson correlations were calculated for each pair of the following three variables: meta-emotions towards mathematics, perceived value of mathematical tasks, and peer relationships.

Fourth, moderation effect analysis. Based on the principles of regression analysis, the PROCESS macro in SPSS was used to test the moderating effect of peer relationships on the relationship between mathematical meta-emotions and the perceived value of mathematical tasks. Furthermore, simple slope analysis was employed to reveal differences in the predictive power of mathematical meta-emotions on the perceived value of mathematical tasks across different levels of peer relationships.

3. Data Characteristics and Analysis of Differences

3.1. The Overall Levels of Secondary School Students' Mathematical Meta-Affect, Task Value and Peer Relationships Are in the Above the Midpoint

The results of the descriptive statistics are shown in Table

1. For mathematical meta-emotion, the average score was 3.83 (SD = 0.79).

Table 1. Descriptive statistics for each variable

Variable	N	Minimum	Maximum	Mean	Standard deviation
Mathematical Meta-Emotions	294	1.10	5.00	3.83	0.79
Value of maths tasks	294	2.14	5.00	3.77	0.61
Peer relationships	294	1.54	4.00	3.14	0.57

The corresponding figures for task value and peer relationships were 3.77 (SD = 0.61) and 3.14 (SD = 0.57), respectively. All three means lay slightly above the midpoint of the respective scales.

3.2. A Significant Difference in the Perceived Value of Maths Tasks was Found Only Between Genders, with Boys Scoring Higher Than Girls

As shown in Table 2, the independent-samples t-test yielded a significant gender difference only for perceived task value ($t = 2.50$, $p < 0.05$), with boys ($M = 3.85$, $SD = 0.61$) outscoring girls ($M = 3.67$, $SD = 0.61$). For mathematical meta-emotion ($t = 0.90$, $p > 0.05$), and peer relationships ($t = 1.88$, $p > 0.05$), the gender differences were not statistically significant.

Table 2. Tests of gender differences for each variable

Dimension	Male (n=162) M± SD	Females (n=132) M± SD	t-value	Significance (two-tailed)
Mathematical meta-emotions	3.86± 0.76	3.77± 0.83	0.90	0.369
Value of mathematical tasks	3.85± 0.61	3.67± 0.61	2.50	0.013
Peer relationships	3.19± 0.55	3.07± 0.57	1.88	0.061

3.3. Second-year Students Scored Significantly Higher Than Both First- And Third-Year Students on Mathematical Meta-Emotion and Task Value

Table 3 summarizes the one-way ANOVA results, which revealed significant grade-level differences for both mathematical meta-emotion ($F = 5.33$, $p < 0.01$), and perceived task value ($F = 3.99$, $p < 0.05$). Post-hoc comparisons using the LSD procedure revealed significant grade-level differences for both meta-emotion and task value. For mathematical meta-emotion, second-year students scored significantly higher ($M = 3.96$, $SD = 0.81$) than their first-year peers ($M = 3.61$, $SD = 0.68$, $p < 0.01$). As for perceived task value, the second-year group again outscored both first-year ($M = 3.68$, $SD = 0.58$) and third-year ($M = 3.68$, $SD = 0.62$) students, with both comparisons reaching significance at $p < 0.05$. Differences in peer relationships among students of different year groups did not reach statistical significance ($F = 0.21$, $p > 0.05$).

Table 3. Test of differences in variables across year groups

Variable	Year 7 (n=85)	Year 2 (n=137)	Year 9 (n=72)	F	P	Post-hoc comparison
Mathematical meta-emotions	3.61 ± 0.68	3.96 ± 0.81	3.81 ± 0.82	5.33	0.005	Year 8 > Year 7
Value of maths tasks	3.68 ± 0.58	3.88 ± 0.62	3.68 ± 0.62	3.99	0.019	Year 8 > Year 7; Year 8 > Year 9
Peer relationships	3.12 ± 0.55	3.16 ± 0.59	3.12 ± 0.55	0.21	0.813	——

3.4. There Were Significant Positive Correlations Between All Pairs of Variables: Mathematical Meta-Emotions, Task Value and Peer Relationships

Table 4. Results of the correlation analysis between variables

Variable	Mathematical meta-emotions	Perceived value of maths tasks	Peer Relationships
Meta-emotions towards mathematics			
Value of mathematical tasks	0.698**		
Peer relationships	0.469**	0.417**	

* Note: ** indicates a significant correlation at the 0.01 level (two-tailed), n=294.

A Pearson correlation analysis was conducted on the variables, with the results shown in Table 4.Mathematical meta-affect was found to be significantly positively correlated with the perceived value of mathematical tasks ($r = 0.698$, $p < 0.01$); mathematical meta-affect was significantly positively correlated with peer relationships ($r = 0.469$, $p < 0.01$); and the perceived value of mathematical tasks was significantly positively correlated with peer relationships ($r = 0.417$, $p < 0.01$).The correlations among these three variables provide a basis for further testing of moderating effects.

3.5. The Hypothesized Moderating Role of Peer Relationships Failed to Reach Statistical Significance.

Model 1 of the SPSS macro PROCESS, developed by Hayes (2013), was used to test the moderating effect of peer relationships on the relationship between mathematical meta-emotions and the perceived value of mathematical tasks. To avoid multicollinearity, the independent variable (mathematical meta-emotions) and the moderator (peer relationships) were mean-centred, and interaction terms were

constructed. Table 5 presents the regression results.

Table 5. Test of the moderating effect of peer relationships on the relationship between mathematical meta-affect and the perceived value of mathematical tasks

Variable	coeff	se	t	p	LLCI	ULCI
Constant term	3.751	0.028	134.708	0.000	3.696	3.806
Mathematical meta-emotion (X)	0.503	0.036	13.836	0.000	0.432	0.575
Partnership (W)	0.121	0.051	2.393	0.017	0.022	0.221
X∗ W	0.097	0.056	1.747	0.082	-0.012	0.207

Regression analysis revealed a significant positive effect of mathematical meta-emotion on task value perception (β = 0.503, t = 13.836, p <0 .001). In contrast, the interaction between meta-emotion and peer relationships was not a significant predictor of task value (β = 0.097, t = 1.747, p = 0.082). This indicates that peer relationships do not exert a significant moderating effect on the relationship between mathematical meta-emotions and the perceived value of mathematical tasks; Hypothesis H2 is therefore not supported.

To further elucidate the predictive trends of mathematical meta-affect on the perceived value of mathematical tasks across different levels of peer relationships, a simple slope analysis was conducted. Simple slope tests at three levels of peer relationships—low (M – 1SD), mean (M), and high (M + 1SD)—yielded coefficients of 0.328, 0.503, and 0.619, respectively (see Table 6), all reaching statistical significance (ps < 0.001); however, the differences between the three slopes were not statistically significant, further corroborating the lack of a significant moderating effect.

Table 6. Predictive slopes of mathematical meta-emotions for the perceived value of mathematical tasks at different levels of peer relationships

Peer relationship level	Slope	se	t	p	LLCI	ULCI
Low (M-SD)	0.328	0.053	6.19	<0.001	0.224	0.432
Medium (M)	0.503	0.036	13.84	<0.001	0.432	0.575
High (M+SD)	0.619	0.051	12.14	<0.001	0.519	0.719

4. Discussion

4.1. Mathematical Meta-Emotions Significantly and Positively Predict the Perceived Value of Mathematical Tasks

The data show that mathematical meta-emotions are positively correlated with the perception of task value and can predict it; thus, H1 is supported. Based on Expectancy-Value Theory, the above results suggest that students' ability to recognise and regulate their emotions can serve as a motive for them to value learning more or less highly [4].

Goldin believed that meta-emotions are necessary to help people overcome emotional barriers in mathematics; therefore, we found that students with a higher level of mathematical meta-emotions are better at recognizing and regulating negative emotions, and consequently, they have more positive evaluations of the task [9]. By functioning as a higher-order affective-cognitive ability, mathematical meta-emotions enable students to reframe the task of learning mathematics in a way that is both achievable and meaningful, thus increasing their intrinsic motivation for learning.

Mathematical meta-emotions strongly predicted task value in our sample (β = 0.503), with the model accounting for approximately 50% of the variance (R^2 = 0.503). These findings point to the potential value of meta-emotional training as a viable avenue for enhancing students' valuation of mathematics.

4.2. Non-significant Moderating Effect of Peer Relationships and Analysis of Reasons

The regression coefficient of peer relationships increased with higher quality of peers (from 0.328 to 0.619), but this moderating effect was not statistically significant (p = 0.082). Therefore, H2 was not verified empirically.

There may be several reasons for the absence of a significant moderating effect; the first is that the peer instrument focuses more on the general relational quality and less on specific interaction patterns, thus it is less sensitive to changes in task-value perception. Secondly, the primary sources of task-value perception are within an individual's emotions and cognitions. Given that mathematical meta-emotions are internal mechanisms and peer relationships are external social resources, they are likely to have a more distal effect and may operate through mediating paths such as self-efficacy and behavioural engagement. Third, the sample consisted of only one school, with limited grade-level and demographic diversity, and therefore may have had a small statistical power to detect the hypothesized moderating effect.

5. Conclusion and Implications

5.1. Research Significance and Educational Implications

The two theoretical contributions of this paper are: It sets up a predictive role for mathematical meta-emotions in task value and raises research on emotions beyond the traditional indicators of anxiety and interest; it moves to the metacognitive level of "emotions about emotions", thus providing a new theoretical foundation for applying Expectancy-Value Theory to lower secondary mathematics education.

Mathematical meta-emotions are thus likely to be the objects of educational intervention in practice. Teachers can add emotional-reflection activities to their math classes to help students recognise and name their emotions; they can also provide explicit training in emotion regulation to motivate students to keep learning despite difficulties, and by cultivating a classroom environment that accepts and acknowledges negative emotions rather than avoiding them, they foster a stronger sense of purpose in life for students.

5.2. Research Limitations and Future Directions

This study has at least three deficiencies that also offer future research directions. Firstly, a cross-sectional design cannot identify cause and effect; therefore, follow-up studies or experiments are needed. Second, by focusing only on peer relationships as a moderator, teacher-student dynamics,

family support, classroom climate, etc., have not been studied; subsequent research could explore these contextual factors simultaneously. Third, as only self-reported data are used, common-method variance problems may occur; to improve both the reliability and depth of subsequent research, interviews, observations or peer nominations could be added.

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