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Exploring the Impact of Growth Mindset on Mathematics Learning Engagement: A Structural Equation Analysis of the Mediating Role of Mathematics Achievement Goals

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Abstract: *This study aims to investigate the relationships among students' growth mindset (GM), mathematics achievement goals (MAG)—including mathematics mastery goals (MMG), mathematics performance-avoidance goals (MPG-av) and mathematics performance-approach goals (MPG-ap)—and mathematics learning engagement (MLE), using a structural equation modeling (SEM) approach. Following preliminary correlation and regression analyses, a structural equation model incorporating two mediators (MMG and MPG-ap) was developed and validated. The findings reveal that: (1) GM, MMG, MPG-ap, and MLE are all significantly and positively correlated; (2) GM, MMG, and MPG-ap significantly predict MLE, with MPG-ap exerting the strongest predictive effect; and (3) both MMG and MPG-ap play significant mediating roles in the relationship between GM and MLE, with the mediating effect of MPG-ap being more pronounced than that of MMG. These results underscore the importance of both belief systems and motivational orientations in shaping students' MLE and provide empirical support for the integration of GM and MAG within the SEM framework.*

Keywords: *Mathematics Learning Engagement; Mathematics Achievement Goals; Growth Mindset*

1. Introduction

The development of positive psychology has sparked a research boom on learning engagement. Learning engagement refers to an individual's level of enthusiasm and involvement in the learning process[1]. A study conducted on students from 34 countries found that more engaged a student is in learning mathematics, the better their mathematics achievement will be[2]. Prior studies have emphasized the significant impact of student engagement on academic success, particularly in mathematics[3]. Therefore, it is crucial to explore the factors that affect students' mathematics learning engagement.

Achievement goal, which originates from the achievement motivation theory, has been widely recognized as a factor that affects learning engagement. Research has found mastery-approach goals can predict behavioral engagement[4]. In math classrooms, when teachers link tasks to daily life, they can improve students' mastery goals orientation and indirectly promote their engagement in math[5]. Thus, it becomes necessary to study the reasons why students choose different achievement goals when learning math. Some researchers believe that the underlying reasons for students' choices of different achievement goals are their beliefs about intelligence plasticity[6].

Mindsets refer to individuals' implicit beliefs about their own intellectual plasticity[7]. Students with a growth mindset hold the belief that intelligence can grow. They prioritize the development of their abilities, and tend to choose mastery goals. Numerous studies have confirmed the correlation between a growth mindset and mathematics achievement[8]. However, there are many misconceptions and practices in education that can reinforce a fixed mindset among students. Mathematics is a discipline that is severely troubled by a fixed mindset. For example, we often hear students say, "Mathematical ability is innate; I am not cut out for studying mathematics." Therefore, studying the influence mechanism of a growth mindset in students' mathematical learning process is of great significance for improving their academic performance.

Although many empirical studies have supported the relationships between two of the three

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constructs—mathematics learning engagement (MLE), mathematics achievement goal (MAG), and growth mindsets (GM)—there are few studies that link all three constructs together. Moreover, in the field of mathematics education, these relationships have been little explored. Recognizing this gap, the present study aims to delve into the intricate interplay among these constructs by deploying a questionnaire survey. Specifically, this study posits the following questions: Is there a significant correlation between MLE, MAG, and GM? Does MAG play a mediating role between GM and MLE?

2. Related Literature

2.1 Mathematics Learning Engagement (MLE)

Learning engagement has undergone a transformation in research focus, shifting from quantity to quality. In the 1940s, Tyler[9] proposed the concept of "time on task" and pointed out that the time students invest in learning is directly proportional to how much they have learned. Research on learning engagement began from that point onward. Later, in 1982, Pace proposed the idea of "quality of effort," emphasizing students' level of focus in the learning process—essentially, the quality of learning engagement. In 1992, Newmann[10] defined engagement as a psychological investment and effort aimed at mastering knowledge, skills, or crafts.

Although scholars have different definitions of learning engagement, most acknowledge it as a multidimensional structure. The three-dimensional structure (behavioral, emotional, and cognitive engagement) has been widely recognized by scholars[11-12]. Behavioral engagement is characterized by the extent of an individual's participates, puts in effort, pays attention, persists in their actions, behaves positively, and avoids negative actions[1]. Emotional engagement is defined by the intensity of an individual's positive or negative responses to their peers, instructors, and the educational process, in addition to their recognition of the institution or specific academic disciplines[13]. Cognitive engagement involves making necessary efforts to master difficult skills or understand complex ideas, which includes willingness, thoughtfulness, and strategic[14]. Therefore, mathematics learning engagement can be defined as students cognitively learning mathematical knowledge, emotionally feeling mathematics as an interesting subject, and behaviorally showing their efforts in learning mathematics, as well as actively participating in mathematics activities.

2.2 Mathematics Achievement Goals (MAG)

Achievement goals reflect an individual's cognitive tendencies toward achievement situations. Elliot et al.[15] conceptualized achievement goals as plans related to cognitive processes, emphasizing the influence of these goals on individuals' behavioral, emotional, and cognitive results in achievement activities. Ames (1992) [16] defined them as a student's perception of the significance or purpose of learning activities, academic achievement, and success. In summary, an achievement goal is characterized by an individual's perception of the significance or purpose of participating in activities related to achievement.

The achievement goals framework has gone through a developmental process. Initially, achievement goal scholars focused on mastery goals and performance goals. Subsequently, performance goals were further divided into approach and avoidance dimensions[17]. Mastery goals emphasize the deep understanding of knowledge, the acquisition of skills, and the development of personal competence. Performance-approach goals highlight showcasing abilities and surpassing peers. On the contrary, performance-avoidance goals focused on avoiding demonstrating low abilities[18]. Although some researchers[19] later proposed mastery-avoidance goals (to avoid losing abilities and skills), most researchers agree with a three-dimensional framework for achievement goals. In this study, a three-dimensional framework was used, including mathematics mastery goal (MMG), mathematics performance-approach goal (MPG-ap), and mathematics performance- avoidance goal (MPG-av).

2.3 Growth Mindset (GM)

Mindset is a belief system related to the malleability of intelligence and continuous learning[20]. Individuals may exhibit a mixture of mindsets, but most people tend to prefer either a growth mindset or a fixed mindset[20]. Those who embrace a growth mindset are of the belief that intelligence can be cultivated and enhanced by persistence and effort. They are more likely to thrive and continue to progress in the face of difficulties. Conversely, individuals who possess a fixed mindset are of the belief that

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intelligence cannot be altered, and as a result, they may avoid challenges[7].

2.4 Relationship between Mindset, Achievement Goals, and Learning Engagement

Mindset and achievement goals are the focus of many researchers' attention regarding their relationship. Dweck and Leggett's 1988 study revealed that students with a fixed mindset tend to be oriented towards performance goals (to get correct answers), and engage in tasks that serve to validate and demonstrate their intelligence. Conversely, students embracing a growth mindset tend to set mastery goals (to gain profound comprehension) and pay more attention to the process involved in grasping concepts and enhancing their skills. While several studies have suggested that people possessing growth mindsets tend to set stronger learning goals (mastery goals) and weaker performance goals when compared to those possessing fixed mindsets[21], some studies have found the opposite to be true. For instance, Ziegler and Stoeger's study[22] found that belief in the changeability of ability deficits (growth mindset) predicted students' performance-approach goals.

Achievement goals also serve as a mediating variable to influence learning engagement. Research has found that achievement goals mediate cognitive needs and mathematics engagement[23]. A mastery goal can regulate the link between students' cognitive engagement and their perception of teacher support in mathematics learning[24]. In math classrooms, students' perceptions of competence support and teaching for meaning are indirectly predict intrinsic motivation and diligence through their mastery goals[5]. However, no research has been conducted to examine the potential mediating effect of students' mathematics achievement goals (MAG) on the relationship between growth mindset (GM) and mathematics learning engagement (MLE). Therefore, this study aims to fill this gap.

3. Methodology

3.1 Respondents and Sampling Procedure

The respondents were students in grades 7, 8, and 9 from three junior high schools in Chaozhou City, Guangdong Province, China. After obtaining permissions from the students, parents, and school administrators, a cluster sampling method was employed to select 39 teaching classes in total, with 13 classes chosen from each grade level. In total, 1950 questionnaires were distributed, and after the elimination of invalid data, there were 1920 valid responses (with a validity rate of 98.5%), including 648 from the 7th grade, 643 from the 8th grade, and 629 from the 9th grade. Among the participants, there were 928 male and 992 female respondents.

3.2 Research Instrument

This study employed a questionnaire consisting of three Likert scales, namely the Mathematics Engagement Scale (MLES), Mathematics Achievement Goals Scale (MAG), and Growth Mindset Scale (GMS). Each item in the questionnaire ranges from 1 (strongly disagree) to 5 (strongly agree).

Mathematics Learning Engagement Scale (MLES). The MLES was adapted from the "Survey Items of Math and Science Engagement" developed by Fredricks et al. (2016)[25], which investigated not only mathematics engagement but also science engagement. According to the research objectives, the MLES used in this study retained items related to mathematics engagement while excluding items related to science engagement. At the same time, considering cultural differences, appropriate adjustments were made to the expression of some items during translation, making it easier for Chinese respondents to understand. The measurement of mathematics learning engagement was based on three dimensions: behavioral engagement (BE),emotional engagement (EE), and cognitive engagement (CE).

Mathematics Achievement Goals Scale (MAGS). The MAGS was adapted from Elliot and McGregor's (2001) [19] Achievement Goals Questionnaire (AGQ). The original AGQ consisted of four subscales: performance-approach, performance-avoidance, mastery-approach, and mastery-avoidance goals. Each subscale comprised three items, totaling 12 items. However, this study removed the "mastery-avoidance goal" subscale based on the conceptual framework and retained only the other three subscales, resulting in a total of nine items. In addition, since the items of the original AGQ were targeted towards all subjects, this study added a mathematics context to the original items to make them more specific to the subject. For example, it changed, "I want to thoroughly master the content in this class" to "I want to thoroughly master the content in math class."

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Growth Mindset Scale (GMS). The GMS was adapted from three mindset scale developed by Dweck et al. in 1995, 1999, and 2006. The 1995 scale measured a fixed mindset with three items[26] . The 1999 scale included four items also measuring a fixed mindset[27]. The 2006 scale consists of four items in total, two of which measure a fixed mindset and two measure a growth mindset[20]. In this study, the GMS was primarily based on the 2006 scale, consisting of four items—two measuring a fixed mindset and two measuring a growth mindset. However, the wording of the items drew inspiration from both the 1995 and 1999 scales. The two items measuring a fixed mindset were scored in reverse. The growth mindset score was obtained by calculating the average score of all four items.

To evaluate the reliability of the three scales, a pilot study was conducted. The results of the study, presented in Table 1, indicate the Cronbach's alpha values for each scale and demonstrate that they were deemed acceptable for the actual study.

Table 1: Reliability of the research instruments.

Scale	Subscale	N of Items	Cronbach's α
MLES	Behavioral Engagement (BE)	10	.935
	Emotional Engagement (EE)	10	.946
	Cognitive Engagement (CE)	7	.833
MAGS	Mathematics Mastery Goals (MMG)	3	.919
	Mathematics Performance-approach Goals (MPG-ap)	3	.884
	Mathematics Performance-avoidance Goals (MPG-av)	3	.952
GMS	Growth Mindset (GM)	2	.843
	Fix Mindset (FM)	2	.882

3.3 Data Processing

This study employed SPSS and AMOS software for data processing and analysis. Initially, analysis of descriptive statistics, correlation, and regression were conducted using SPSS to investigate the current status of, and relationships among, students' mathematics learning engagement, mathematics achievement goals, and growth mindset. Subsequently, based on these initial findings, a structural equation model (SEM) was constructed and its fit, as well as the effects of mediating pathways, was tested using AMOS software.

4. Research Results

4.1 Results of Descriptive Statistics and Correlation Analysis

To explore the current status and correlations among participants' growth mindset, achievement goals, and engagement in mathematics learning, we conducted descriptive statistical analyses and correlation studies on the collected data, with the results presented in Table 2.

Table 2: Mean, Standard Deviation, and Correlation Matrix.

	Mean	SD	1	2	3	4	5	6	7	8
1.GM	3.53	1.22	1							
2.MMG	4.17	1.07	.459**	1						
3.MPG-ap	4.02	1.06	.540**	.400**	1					
4.MPG-av	2.50	1.31	-.029	.083	.111	1				
5.BE	3.83	0.88	.409**	.342**	.379**	.122	1			
6.EE	3.42	0.99	.372**	.457**	.500**	.125	.405**	1		
7.CE	3.87	0.70	.367**	.252**	.304**	.121	.203**	.216**	1	
8.MLE	3.71	0.62	.527**	.497**	.556**	.169	.761**	.801**	.582**	1

As indicated in Table 2, students generally exhibit a growth mindset (GM), though it is at a medium level (Mean = 3.53). They show strong agreement with striving for mathematics mastery goals (MMG, Mean = 4.17) and performance-approach goals (MPG-ap, Mean = 4.02), yet they tend to disagree with the pursuit of mathematics performance-avoidance goals (MPG-av, Mean = 2.5). The level of mathematics learning engagement (MLE) is medium (Mean=3.71), with cognitive engagement (CE) being the most prominent, followed by behavioral engagement (BE), and emotional engagement (EE) being the least. There is a significant positive correlation between GM and both MMG and MPG-ap, as well as across all dimensions of MLE; however, GM shows no correlation with MPG-av. Similarly, MLE is significantly positively correlated with MMG and MPG-ap, but it has no correlation with MPG-av. These findings elucidate the strong interrelationships among the variables of GM, MMG, MPG-ap, and MLE.

4.2 Results of Regression Analysis

To enhance our understanding of the effects that a growth mindset (GM), mathematics mastery goals (MMG), and mathematics performance-approach goals (MPG-ap) have on mathematics learning engagement (MLE), we employed multiple linear regression analysis. In this model, MLE serves as the dependent variable, while GM, MMG, and MPG-ap are the independent variables. The outcomes of the analysis are presented in Table 3. As gleaned from Table 3, the multiple correlation coefficient, which ties the three independent variables to MLE, stands at 0.658, and its squared value is 0.433. This indicates that GM, MMG, and MPG-ap together explain 43.3% of the variance in MLE. This statistic reveals that, collectively, the trio of predictor variables accounts for a substantial proportion of the variance within the MLE criterion variable. The regression model reached statistical significance ($p = 0.000$), comfortably below the 0.05 threshold, confirming that the model is robust and significantly explains the variance. Our standardized regression equation is structured as follows: MLE = 0.230 × GM + 0.260 × MMG + 0.328 × MPG-ap.

Given that each of the standardized regression coefficients for the independent variables is positive, it is clear that they all positively influence MLE. The t-values for the regression coefficients' significance tests are 3.747, 4.620, and 5.515, respectively, with $p<0.001$, establishing that these coefficients are statistically significant. This affirms that GM, MMG, and MPG-ap are substantial and positive predictors of MLE, with MPG-ap emerging as the most potent predictor among them.

Table 3: Summary of Regression Analysis.

Independent Variables	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	1.888	.144		13.125	.000		
GM	.117	.031	.230	3.747	.000	.638	1.567
MMG	.151	.033	.260	4.620	.000	.757	1.322
MPG-ap	.194	.035	.328	5.515	.000	.679	1.473
Dependent Variable: MLE							
$R=0.658$, $R^2=0.433$, Adjusted $R^2=0.426$, $F=60.097$***							

4.3 Results of Model Fit Verification

Drawing from the above regression analysis findings and integrating insights from the existing literature conclusions, this study constructed a structural model (Figure 1). This model postulates that two parallel mediators (MMG and MPG-ap) operate, offering two mediation paths: (1) GM→MMG→MLE; (2) GM→MPG-ap→MLE.

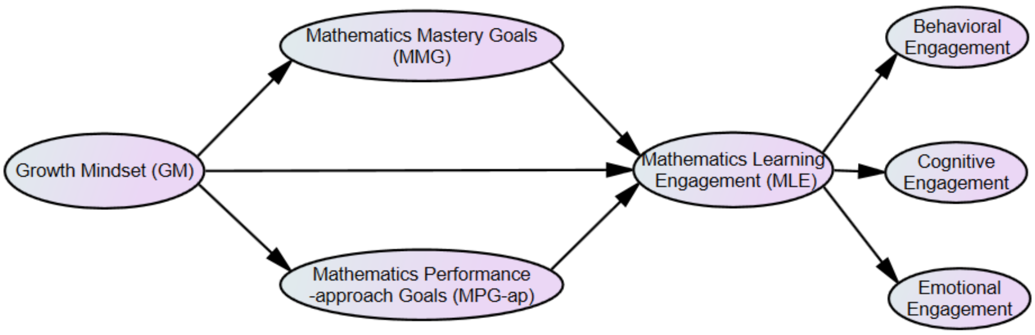

Figure 1: Research Model.

The fit of the research model was validated in Amos, with results presented in Table 4 and Figure 2. The Research Model, with 119 estimated parameters, demonstrates an acceptable level of fit to the data, as indicated by several fit indices. While the chi-square test is significant (CMIN=5997.125, $p<.001$), suggesting a poor fit, the large sample size may have contributed to this significance. Therefore, we look

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at other fit measures for a more nuanced evaluation. The comparative fit indices such as the NFI, IFI, TLI, and CFI are all below 0.9 but close to this value, suggesting that the model has a moderate to good fit compared to the null model. The parsimony-adjusted measures (PNFI and PCFI), which consider model complexity, also indicate a relatively good balance between fit and parsimony.The RMSEA value for the Research Model is 0.067, which falls within the acceptable range (below 0.08), suggesting that the model adequately approximates the population covariance matrix. In conclusion, while the significant chi-square value might initially imply a poor fit for the Research Model, other fit indices suggest it has an acceptable fit to the data. It strikes a good balance between accurately representing the data and maintaining parsimony, making it a reasonably well-fitting model according to SEM standards.

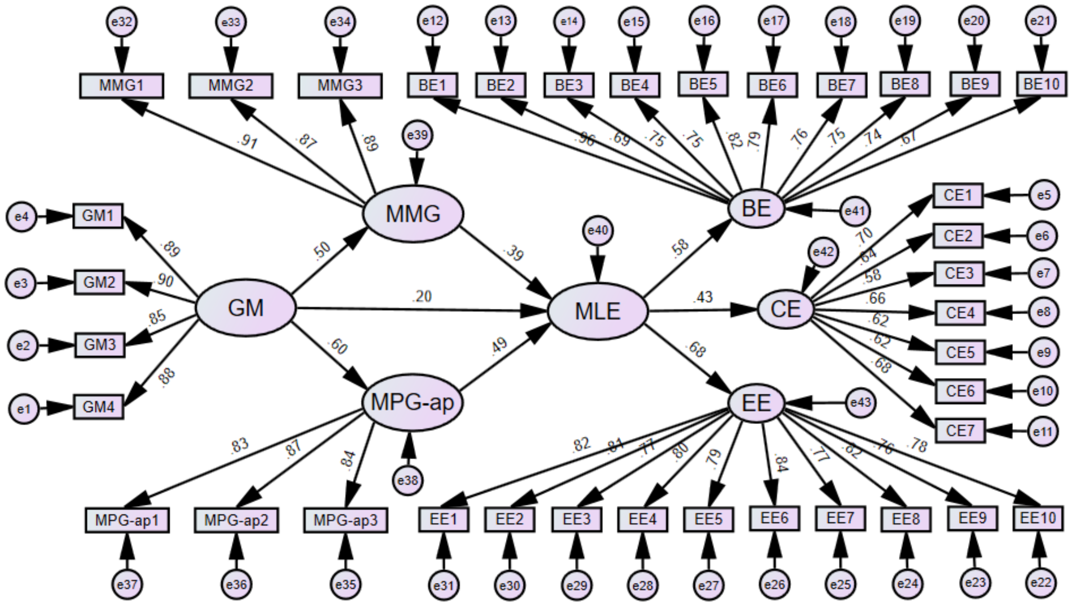

Figure 2: Results of Model Fit Verification.

Table 4: Model Fit Summary.

NPAR	Chi-Square	p	NFI	IFI	TLI	CFI	PNFI	PCFI	RMSEA
119	5997.125	.000	.888	.898	.890	.898	.828	.837	.067

4.4 Results of Path Coefficient Analysis

Path coefficients, in contrast to regression coefficients, can elucidate the causal links among variables. To explore how a growth mindset (GM) affects mathematics mastery goals (MMG), mathematics performance- approach goals (MPG-ap), and mathematics learning engagement (MLE), as well as to assess the influence of both MPG-ap and MMG on MLE, the research model's path coefficients were rigorously analyzed. The findings, detailed in Table 5 and illustrated in Figure 2, reveal that the relationships between all variables are statistically significant. The study uncovers that GM exerts a positive influence on MMG, MPG-ap, and MLE; moreover, MPG-ap has a beneficial impact on MLE, as does MMG.

Table 5: Results of Path Coefficient Analysis.

Path between variables			Standardization coefficient	Unstandardization coefficient	S.E.	C.R.
MMG	←	GM	.50	.45	.020	21.97***
MPG-ap	←	GM	.60	.51	.020	25.58***
MLE	←	GM	.20	.09	.016	5.54***
MLE	←	MPG-ap	.49	.27	.020	13.60***
MLE	←	MMG	.39	.20	.016	12.47***

4.5 Results of Mediation Effect Analysis

The Bootstrap method was utilized to examine the effects of two parallel mediators, with the findings detailed in Table 6. According to Table 6, it is evident that GM has a significant direct effect on MLE,

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and the mediating effects of MMG and MPG-ap are also significant. The indirect effect mediated by MMG is estimated at 0.090, accounting for 28.2% of the total effect. Furthermore, The indirect effect mediated by MPG-ap is estimated at 0.138, constituting 43.3% of the total effect. The proportion of these effects indicates that indirect pathways, especially through MPG-ap, play a significant role in the relationship between the independent and dependent variables. Direct effects still exist but are less dominant compared to the indirect effect via MPG-ap, suggesting that understanding the mediators gives a more nuanced insight into the cause and effect relationship being studied.

Table 6: Results of Mediation Effect Analysis.

Type	Estimate	SE	95%Lower	95%Upper	Proportion of total effect
Total effect	.319***	.020	.263	.481	
Direct effect	.091***	.023	.084	.093	28.5%
Indirect effect of MMG	.090***	.008	.083	.092	28.2%
Indirect effect of MPG-ap	.138***	.013	.124	.155	43.3%

5. Conclusion and Discussion

This study aims to examine how students' growth mindset (GM) relates to their mathematics achievement goals (MAG) and overall engagement in learning mathematics (MLE). The findings suggest that GM shows a clear positive association with mathematics mastery goals (MMG), mathematics performance-approach goals (MPG-ap), and MLE. In particular, students with stronger growth mindsets tend to demonstrate higher levels of learning engagement, and both MMG and MPG-ap play meaningful roles in explaining this link. Among the two, the performance-approach goals (MPG-ap) appear to have a slightly stronger predictive influence on engagement. Furthermore, the analysis reveals that MMG and MPG-ap act as mediators in the connection between GM and MLE, with MPG-ap exerting a more substantial mediating effect than MMG.

5.1 Implications of the Predictive Relationships

One important outcome of this research is that both mathematics mastery goals (MMG) and performance-approach goals (MPG-ap) serve as meaningful predictors of mathematics learning engagement (MLE). This suggests that students are motivated to engage in mathematics not only by a desire to master the material but also by the drive to perform well relative to others. Notably, the stronger predictive effect of MPG-ap compared with MMG may mirror the realities of the current educational climate in Chinese junior high schools, where external incentives, academic competition, and peer comparison are prominent motivational forces. This observation is in line with Elliot and Church's[28] argument that performance-approach goals can promote engagement and achievement, particularly in contexts where academic stakes are high.

Even so, performance-oriented goals should not be viewed as universally advantageous. Although they can temporarily boost motivation, such goals may also heighten students' anxiety and encourage surface-level learning when intrinsic motivation is lacking[29]. By contrast, mastery goals—despite showing a weaker predictive effect in this study—tend to cultivate deeper understanding and persistence when learners encounter difficulties[16]. Hence, it would be beneficial for educators to nurture classroom environments that value both improvement and accomplishment, helping students maintain a healthy balance between mastery and performance orientations.

5.2 The Dual Pathways of Growth Mindset

The findings of this study suggest that a growth mindset (GM) influences mathematics learning engagement (MLE) through two interconnected motivational pathways. The mediating effects of mathematics mastery goals (MMG) and performance-approach goals (MPG-ap) shed light on how these mechanisms operate in practice. In essence, GM appears to foster both mastery-oriented and performance-driven motivations, which together contribute to students' active participation in mathematics learning. This dual-pathway pattern implies that learners with a growth mindset are encouraged not only by an inner desire to improve their mathematical understanding but also by a competitive impulse to excel—an interplay that is nuanced and shaped by the surrounding educational context.

The fact that MPG-ap plays a stronger mediating role suggests that within highly competitive academic environments, a growth mindset may more readily align with performance-based motivations than with purely mastery-focused ones. Such a tendency provides an important extension to Dweck's[20] framework: while her theory emphasizes persistence and learning through effort and failure, it pays less attention to how contextual pressures can redirect motivational energy. Future models of GM would therefore benefit from incorporating cultural and institutional dimensions to better capture how individuals translate their beliefs about growth into specific goals and learning behaviors.

5.3 Critical Reflections and Educational Significance

While the present study affirms that both mathematics mastery goals (MMG) and performance-approach goals (MPG-ap) play meaningful motivational roles, it also opens up several questions that merit further attention.

First, to what extent is the pursuit of MPG-ap actually beneficial? Although this goal orientation can promote mathematics learning engagement (MLE), an overdependence on external approval may heighten the risk of emotional exhaustion and discourage students from taking intellectual risks.

Second, how might educators strengthen MMG without diminishing the positive energy that often comes from healthy competition? Approaches such as emphasizing learning processes in feedback, incorporating self-referenced assessments, and providing structured opportunities for goal setting could help guide students toward mastery-focused motivations, even in classrooms where performance comparisons are unavoidable.

Moreover, the notion of a growth mindset (GM)—understood as one's implicit belief in the potential to develop intellectual ability—appears to shape how learners interpret both success and failure. Yet, this influence may not operate in a uniform way. Rather, it seems to be filtered through broader cultural and institutional factors, including school climate and perceived expectations from teachers and parents. Consequently, nurturing a growth mindset should extend beyond encouraging effort; it also requires aligning educational messages, assessment practices, and classroom norms to cultivate genuinely adaptive motivational patterns.

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