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Research Article

Mathematical resilience and mathematical modeling competency: Exploring the mediation effect of subjective academic well-being

Ali Zengin[1] and Veysel Akçakın[2]

[1]*Institute of Graduate Education, Usak University, Usak, Türkiye (ORCID: 0000-0002-8576-8734)*
[2]*Mathematics Education, Uşak University, Türkiye (ORCID: 0000-0002-7705-0722)*

The present study aimed to explore the mediating role of subjective academic well-being in the relationship between the three dimensions of mathematical resilience (value, struggle, and growth) and mathematical modeling competency among fifth grade students, as well as the moderating effect of gender on this relationship. The participants in this cross-sectional study consisted of 615 fifth-grade students, of whom 50.4% were female and 49.6% were male, with ages ranging from 10 to 13 years. A cross-sectional survey design was employed, utilizing a mathematical modeling test, mathematical resilience scale, and subjective academic well-being scale. The results indicated a positive and significant relationship between mathematical modeling competency, mathematical resilience, and subjective academic well-being. Multiple group mediation analysis revealed that the effect of value on mathematical modeling competency was mediated by subjective academic well-being. However, the dimensions of struggle and growth of mathematical resilience did not predict mathematical modeling competency through subjective academic well-being, although growth was found to predict mathematical modeling competency directly. Pairwise parameter comparisons showed no significant gender differences in the multiple group mediation analysis.

Keywords: Elementary school; Mathematical modeling; Mathematical resilience; Multiple group mediation analysis; Well-being

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1. Introduction

Despite the many studies on mathematics education, many problems have essentially persisted and not much progress has been made. In addition, gender gaps in mathematics achievement persist, underscoring the need for a more nuanced understanding of the variables influencing students' performance (Seah, 2019). In Türkiye, for example, students' performance on the Trends in International Mathematics and Science Study [TIMMS] and Programme for International Student Assessment [PISA] assessments has remained almost constant (Organization for Economic Co-operation and Development [OECD], 2023; von Davier et al., 2024). The results of the national Monitoring and Evaluation of Academic Skills examination are similarly revealing (Ministry of National Education of Türkiye [MoNE], 2019). In this respect, the question "Have we missed out

Address of Corresponding Author

Veysel Akçakın, PhD, Uşak University, Faculty of Education, Department of Mathematics Education, 64000, Uşak, Türkiye.

veyselakcakin@gmail.com

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some important variable(s) in our research?" arises (Seah, 2019, p. 100). In this respect, we think that mathematics education research should also be looked at from the psychological dimension. "For two hundred years many psychologists took for granted that the study of mind could be divided into three parts: cognition, affection, and conation" (Hilgard, 1980, p. 107).

Studies on mathematics education, however, typically focus on cognitive characteristics (Bücker et al., 2018), some also explore affective characteristics (Hannula, 2020). Additionally, research has examined conative characteristics (Seah, 2019), but these studies generally emphasize negative affective traits. This study was conducted to address this gap in literature and to explore the mechanisms linking mathematical resilience [MR], mathematical modeling competency [MMC], and subjective academic well-being [SAW]. These factors –MR, SAW, and mathematics achievement in the context of MMC– are key indicators of positive psychological functioning (Lee & Johnston-Wilder, 2017) and are central to the present study. They also play a crucial role in identifying the characteristics of high-performing educational systems (OECD, 2017). Furthermore, schools serve not only as places for students to develop academic skills but also as environments where they interact with others, shape their identities, and engage with various aspects of society, all of which influence their subjective well-being (Bücker et al., 2018). Developed countries focus not only on mathematics achievement but also on students' well-being (Seah, 2019). Additionally, despite many studies showing general validity, if we examine TIMSS and PISA achievement in Türkiye or Australia etc., it is evident that there has not been much progress (OECD, 2023; von Davier et al., 2024). Perhaps the reason for this is that the mechanisms of conative traits, which consider cognitive and affective variables alongside behavior, have not been fully uncovered. This is because conative traits are the bridge among the cognitive and affective traits and behavior (Seah, 2019). Additionally, Bishop (1999) states that values are "deep affective qualities." However, in the literature, values are also seen as being defined by their affective and conative meanings (Law, 2024). If a value consists solely of emotional responses to things we care about, it should be considered an affective trait. On the other hand, if the things we value are oriented toward action and motivation, they should be regarded as a conative trait (Tiberius, 2018).

Accordingly, the affective aspect of value involves the emotional responses and sense of meaning that a student has regarding mathematical learning, while the conative aspect pertains to how intentionally and actively the student embraces this learning. On the other hand, well-being is considered the ultimate value (Hill & Seah, 2023; Tiberius, 2018). In this context, well-being is regarded as a conative trait in this study, as it integrates individuals' cognitive and emotional responses to life experiences, and because the way people assess their subjective state is directly related to action and motivation (Burke et al., 2024; Oishi et al., 2021). Therefore, in the present study, when MR is considered with its three dimensions (value, struggle, and growth), 'value' is regarded as an affective trait because the meaning that students attribute to mathematical processes and challenges is shaped in an emotional context (Kooken et al., 2016). In this vein, in the present study, MMC was considered as cognition, MR (value, struggle, and growth) as affection, and SAW as conation. The relationships among these three measures were explored. This is because the OECD states that academic excellence should be promoted through students' well-being, not at the expense of it (OECD, 2023). In this respect, the present study is important in terms of providing empirical knowledge on the conative role of well-being between affective and cognitive traits.

1.1. Mathematical Resilience, Subjective Academic Well-Being and Mathematical Performance

Psychological resilience refers to the capacity of individuals to overcome the challenges they face and provides the best adaptation despite adverse conditions (Vera Gil, 2024). MR, on the other hand, can be understood as the ability to maintain a solution-focused and optimistic approach when confronted with challenges or obstacles related to mathematics, rather than giving in to negativity (Kooken et al., 2013; Lee & Johnston-Wilder, 2017) and is a desirable characteristic for all students (Kooken et al., 2016). MR consists of three dimensions: value, struggle, and growth. The dimension of "value" in MR refers to the extent to which students perceive the study of mathematics as important in achieving their current or future goals. The dimension of "struggle" contributes significantly by identifying the characteristics that enable students to persevere in mathematics when confronted with challenges. The dimension of "growth" refers to the belief that mathematics can be learned by anyone and is not limited to those with a predisposition or a math gene (Kooken et al., 2016).

Subjective well-being refers to how a person evaluates their life in emotional and cognitive terms, including specific domains such as education and the learning process, along with various other areas of life (Oishi et al., 2021). Similarly, SAW is a student's perceptions of positive experiences such as academic achievement and is a strong indicator of domain-specific well-being (Arslan et al., 2022). It is reported that individuals who are psychologically resilient have increased subjective well-being (Arslan et al., 2024; Arslan & Wong, 2024; Bajaj et al., 2022) and have a high desire to continue school (Olsson et al., 2003). In addition, SAW has a great predictive effect on academic achievement (Arslan et al., 2022). Achieving academic achievement at the cost of students' well-being cannot be considered a complete accomplishment (OECD, 2015). Furthermore, happiness and education are deeply intertwined; education should aim to foster happiness, and a quality education plays a significant role in enhancing both individual and collective well-being (Noddings, 2003). In this respect, subjective well-being may serve as a mediating factor in the relationship between MR and mathematics performance. In fact, there is a high positive correlation between well-being and math performance (Arslan et al., 2022; Bücker et al., 2018). However, well-being cannot be achieved without resilience, and one cannot develop resilience if one is protected from difficulties, one must be exposed to difficulties and learn to overcome them (Maddux, 2021). This is because it is normal for students to struggle in mathematics and it is crucial that they attribute these struggles to the mathematical content and rather than to their own abilities. By recognizing that mathematical difficulties are common for all students and experts, students become more tolerant and resilient to setbacks (Kooken et al., 2013). The significance of fostering MR in learners stems from the necessity of incorporating positive psychology into mathematics instruction (Lee & Johnston-Wilder, 2024a).

1.2. Mathematical Modeling Competency

Mathematical modeling and its applications, which are an important element of mathematical literacy, enable individuals to better understand their environment, improve their problem-solving skills, and strengthen their ability to generate knowledge and strategies in various disciplines by effectively using mathematical knowledge in a real-world context (Cevikbas et al., 2025). Although there are different cyclical approaches to developing modeling competency, the ultimate goal is to develop a holistic competency (Blum & Niss, 2024). This process includes how mathematical concepts can be used in practice, as it involves bidirectional transitions from the mathematical world to the real world (Borromeo-Ferri, 2018). Thus, it supports students to learn mathematics in a more meaningful way and to relate it to their lives. In addition, mathematical modeling is a fundamental skill for careers in many disciplines (Siller et al., 2024). Moreover, critical evaluation of public communications using modeling is an important competency for responsible citizenship. For this reason, modeling is increasingly being included in the curricula and policy documents of more and more countries (Geiger et al., 2025), and much research has been conducted on the factors that influence the development of modeling competency in this process (Blum & Niss, 2024; Borromeo-Ferri, 2018; Cevikbas et al., 2022; Cevikbas et al., 2025; English, 2024; Geiger et al., 2025; Greefrath et al., 2018; Julie, 2020; Schukajlow et al., 2023; Spreitzer et al., 2024). For example, Geiger et al. (2025) identified different dimensions of enablers and un-enablers affecting mathematical modeling processes and made important implications for teaching practices and future research.

However, although these studies have provided important insights on how to support modeling competency, there are still many uncertainties and unresolved issues related to teaching and learning processes. This is because these and previous studies did not consider conative variables (Hill & Seah, 2023; Reitan & Wolfson, 2000; Seah, 2019), and we did not find any study that examined the role of conative variables on MMC in our literature review.

1.3. Gender Differences

Subjective well-being of females shows that they generally experience fewer positive emotions and more negative emotions compared to males (Blanchflower & Bryson, 2024). Furthermore, it has been suggested that both subjective well-being and academic achievement may vary by gender, with these differences becoming more noticeable as students progress through higher grade levels. This is because girls tend to get higher grades than boys, but despite this, girls may evaluate themselves negatively and have more concerns about their performance in school (Bücker et al., 2018). This difference between genders is referred to as the gender well-being gap, and there is an emphasis on the concern it raises and the need to investigate its effects (Blanchflower & Bryson, 2024).

Oberleiter et al. (2023) conducted an analysis of academic performance in reading literacy, mathematics, and science across 16 cohorts in 90 different countries from 1995 to 2019. Their findings revealed that female students outperform male students in all three subjects. However, the advantage of females in mathematics and science is shaped by factors like the levels of gender equality and the country's economic conditions. Moreover, they found larger gender gaps in math and science in egalitarian and prosperous countries (Oberleiter et al., 2023). According to the 2019 exam results, while there is a result in favor of males in 4th grade, there is a result in favor of females in 8th grade in mathematics achievement in Türkiye (Mullis et al., 2020). Gender differences in mathematics can occur especially against females during the difficulties faced by males, and this difference is due to the fact that females –especially those who believe that talent is innate– are weaker in coping with difficulty and complexity (Dweck, 2007). In the literature on resilience, there are studies showing that females are more resilient than males or males are more resilient than females, and there are also studies showing that there are no gender differences in resilience (Vera Gil, 2024).

2. The Purpose of the Current Study

Modeling processes are defined by their flexible nature and built-in uncertainty (Kaiser, 2007), which leads to mathematical modeling problems being solvable by multiple methods and resulting in multiple possible outcomes (Schukajlow et al., 2023). In this process, achieving a solution cyclically requires a challenging bidirectional translation for students between the mathematical world and real-world phenomena (Borromeo-Ferri, 2018). Cognitive and behavioral barriers may emerge during various stages of the modeling process (Cevikbas et al., 2022; 2025). These barriers can negatively impact the development of modeling competency and, consequently, hinder the advancement of cognitive and affective traits. This may be due to the mechanisms of conative traits, which address cognitive and emotional variables in interaction with behavior, not yet being fully uncovered. Conative traits serve as a bridge between cognitive and emotional attributes and behavior (Seah, 2019). Since well-being is considered the ultimate value (Hill & Seah, 2023; Tiberius, 2018), and values are also conative traits (Seah, 2019), well-being is regarded as a conative trait in this study. Well-being reflects an individual's subjective evaluation of their state by integrating cognitive assessments and emotional responses to life experiences (Burke et al., 2024). In this context, understanding the impact of well-being on students' modeling competency could play a critical role in overcoming these barriers and enhancing achievement in the modeling process.

Individuals with MR are able to use mathematical thinking to model and make sense of the world (Lee & Johnston-Wilder, 2024a). This suggests that MR can affect MMC. Additionally, to create a learning environment that strengthens MR, every step of mathematics teaching should be planned with consideration of the student's well-being. Helping students gain MR requires the integration of positive psychology into mathematics teaching (Lee & Johnston-Wilder, 2024a).

Considering all these together, well-being may have a mediating role in the relationship between MR and MMC. The present study was conducted to reveal this mechanism by taking gender into consideration. Because in the literature on resilience, there are studies showing that girls are more resilient than boys or boys are more resilient than girls, and there are also studies showing that there are no gender differences in resilience (Vera Gil, 2024).

Although previous research has demonstrated that MR is associated with positive psychosocial and academic outcomes in students, including their academic achievement and well-being, further exploration is needed to understand the mechanisms that explain this relationship, particularly in relation to students' academic functions. Specifically, does MR directly affect MMC, or is the effect mediated through SAW? Furthermore, it remains unclear whether such a relationship varies between female and male students. These questions warrant further investigation. To address this gap in the literature, the present cross-sectional study seeks to examine the mediating role of SAW in the relationship between the three dimensions of MR (value, struggle, and growth) and MMC among fifth-grade students, as well as the moderating effect of gender on this relationship.

The hypotheses of the study are outlined below:

H1: Each of the three dimensions of MR (value, struggle, and growth) significantly predicts MMC, and this relationship is moderated by gender.

H2: Each of the three dimensions of MR (value, struggle, and growth) significantly predicts SAW, and this relationship is moderated by gender.

H3: SAW significantly predicts MMC, and this relationship is moderated by gender.

H4: The relationship between each of the three dimensions of MR(value, struggle, and growth) and MMC is mediated by SAW, and this relationship is moderated by gender.

3. Method

3.1. Research Design

This study employed a cross-sectional research design, where data were gathered from the selected sample at one time point (Fraenkel et al., 2012). Data were collected from five different schools with varying socioeconomic levels.

3.2. Participants

The participants in this study consisted of 615 fifth-grade students. Of these students, 310 were female and 305 were male, with ages ranging from 10 to 13 years (M = 10.89, SD = 0.52). A paper-based survey was used for data collection. Prior to distributing the scales, students were informed that their responses would remain confidential and would solely be utilized for research purposes. Only those students who consented to participate completed the survey.

3.3. Instruments

Data were collected with Mathematical Modeling Test, Subjective Academic Well-Being, and Mathematical Resilience scales.

3.3.1. Mathematical modeling

Students' performance in mathematics was evaluated using 15 mathematical modeling items. Weighted Likelihood Estimation [WLE] (Warm, 1989) was employed to obtain individual student scores, with the WLEs computed using the ACER Conquest version 5. The item-total correlations ranged from .29 to .70. Item discrimination indices varied between .60 and 3.24. Item difficulty (2PL) ranged from -0.797 to 2.784. Infit Mean Square [MNSQ] values ranged from .93 to 1.03, and Outfit MNSQ values ranged from .96 to 1.20. Since the MNSQ values are between 0.6 and 1.4, the fit values are within acceptable limits (Wright et al., 1994). The expected-a-posteriori/plausible-values reliability [EAP/PV] was .701, and the Cronbach's alpha reliability was .72.

3.3.2. Subjective academic well-being

Subjective Academic Well-Being [SAW] scale consists of six items designed to evaluate positive academic functioning among students. Participants rate their responses on a 5-point scale, ranging from "almost never" (1) to "almost always" (5). The SAW scale demonstrated satisfactory internal reliability estimates among Turkish students. Higher scores on the scale indicate a greater level of positive academic functioning in school. To obtain the composite score, all items are summed, with higher scores reflecting higher levels of SAW (Arslan et al., 2022).

3.3.3. Mathematical resilience

Mathematical Resilience [MR] scale developed by Kooken et al. (2016) consists of twenty-four items and three factors namely value, struggle, growth. Participants rate their responses on a 5-point scale, ranging from "strongly disagree" (1) to "strongly agree" (5). High scores indicate that students demonstrate greater resilience when confronted with challenges in mathematics. For instance, a high score in the growth dimension reflects a strong growth mindset. The psychometric validity of the scale for 5th grade was examined in the present study. The items with low factor loadings (items 18, 21, 15, 10, and 9) were sequentially removed, and the analysis was repeated. Based on the CFA conducted with the remaining 19 items, the factor loadings ranged from .40 to .84, and the measurement model indicated adequate data model fit statistics: $\chi^2(149) = 506.50$, $p < .001$, CFI = .91, RMSEA = .063 (90% CI [.057, .069]), SRMR = .063.

3.4. Data Analysis

First, the construct validity of the measures was examined. The normality assumption was assessed using kurtosis and skewness scores, and correlation estimates were computed to determine the relationships between the measures. The structural properties of the mathematical modeling measures was analyzed using Conquest (Adams et al., 2020), while the structural validity of other measures and the multiple group mediation analysis were examined with Mplus 8.10 (Muthén & Muthén, 2017). The significance of indirect effects was assessed using the bootstrap method with 95% confidence intervals and 5000 resamples. According to the bootstrap method, for mediation effects to be significant, the 95% confidence intervals must not include zero (MacKinnon, 2012). Subsequently, the role of gender in the relationship between MR and MMC, mediated by SAW, was examined through multiple group mediation analysis. The significance of differences between groups was evaluated using pairwise parameter comparisons. Critical values for z-scores in group comparisons were set at 1.96, 2.58, and 3.29 for significance levels of .05, .01, and .001, respectively.

4. Results

4.1. Preliminary Analysis

The observed scale characteristics and correlation results for the measures in the study are presented in Table 1. The skewness and kurtosis values indicate that all scales in the study are relatively normally distributed (Hair et al., 2022). Thus, we used ML estimator in conjunction with Full Information Maximum Likelihood [FIML] to handle missing data. The measures also have internal reliability estimates ranging from 0.72 to 0.88 for the study sample. The correlation results indicate small to moderate positive correlations between the measured characteristics. SAW has a high correlation with MMC, value, and struggle, and a small correlation with growth. Similarly, MMC has a moderate correlation with value, struggle, and growth.

Table 1
Characteristics of the Observed Measures and Correlation Results

	Descriptive statistics							*Correlations*				
Scales	a	Min.	Max	*M*	*SD*	Skew.	Kurt.	1.	2.	3.	4.	5.
1. SAW	.76	1	5	3.86	.81	−.96	.96	–	.260**	.557**	.405**	.074
2. MMC	.72	−3.08	4.71	.012	1.23	−.513	1.085		–	.215**	.213**	.260**
3. Value	.88	1	5	3.92	.84	−1.280	1.863			–	.567**	.041
4. Struggle	.75	1	5	3.89	.79	−1.256	1.996				–	.025
5. Growth	.76	1	5	3.50	.98	−.626	−.184					–

Note. SAW = Subjective Academic Well-Being. MMC = Mathematical Modeling Competency; ***p* < .01; **p* < .05

4.2. Primary Analyses

The measurement model was evaluated prior to conducting the multiple group mediation analysis. The results revealed favorable data-model fit indices, suggesting that the model provides a good fit: $\chi^2(269) = 714.224$, $p < .001$, CFI = .90, SRMR = .056, RMSEA (90% CI) = .052 (.047, .057). All factor loadings were found to be statistically significant, ranging from .40 to .83. Following the evaluation of the measurement model, the structural model was also assessed. The data-model fit indices for the structural model indicated a good fit: $\chi^2(290) = 773.812$, $p < .001$, CFI = .90, SRMR = .056, RMSEA (90% CI) = .052 (.048, .057). As with the measurement model, all factor loadings were significant, ranging from .40 to .83.

4.2.1. Multiple group mediation analyses

The research question, "Do students' MR dimensions (value, struggle, and growth) affect their MMC through their SAW, and is this relationship moderated by gender?" was examined through multiple group mediation analysis. This analysis explored the relationship between students' MR and their MMC, with SAW considered as a potential mediator, and gender as a moderating factor. The findings, presented in Table 2, reveal key insights into this relationship.

Two dimensions of MR, struggle ($\beta = .159$, $p < .05$) and growth ($\beta = .300$, $p < .05$) were significant predictors of MMC, supporting Hypothesis 1 (H_1). However, the value dimension did not show a significant relationship with MMC ($\beta = .121$, $p > .05$), meaning that H_1 was not supported for value. In total, MR accounted for 18% of the variance in MMC, highlighting its significant role in shaping students' MMC. Additionally, the analysis tested Hypotheses 2, 3, and 4, with SAW as the mediator variable (see Figure 1). The results indicated that value significantly predicted SAW ($\beta = .575$, $p < .05$), supporting Hypothesis 2 (H_2). However, neither struggle ($\beta = .144$, $p > .05$) nor growth ($\beta = .078$, $p > .05$) significantly predicted SAW, so H_2 was not supported for either of these variables. Furthermore, the effect of SAW on MMC was significant ($\beta = .166$, $p < .05$), supporting Hypothesis 3 (H_3). However, only the path from growth to MMC ($\beta = .287$, $p < .05$) was significant, while the paths from value ($\beta = .026$, $p > .05$) and struggle ($\beta = .135$, $p > .05$) to MMC were not significant. To test the indirect effects of SAW as a mediator, a path analysis using the bootstrap method was conducted with 5000 resampling iterations. The bootstrap results showed that the indirect effect of value on MMC through SAW was significant ($\beta = .095$, 95% CI [.014, .190]), supporting Hypothesis 4 (H_4). However, the indirect effects of struggle ($\beta = .024$, 95% CI [−.002, .061]) and growth ($\beta = .013$, 95% CI [−.002, .035]) on MMC were not significant, as their confidence intervals included zero.

In the multiple group mediation analysis with gender as a moderator, the findings indicated that growth was a significant predictor of MMC for both genders, while value and struggle were not significant predictors of MMC for either gender. The structural model analysis showed that value significantly predicted SAW for female students, but not for male students. The effect of struggle on SAW was statistically significant for male students but not for female students, and growth did not significantly predict SAW for either gender. Moreover, the effect of SAW on MMC was statistically significant for female students, but not for male students. When MMC was

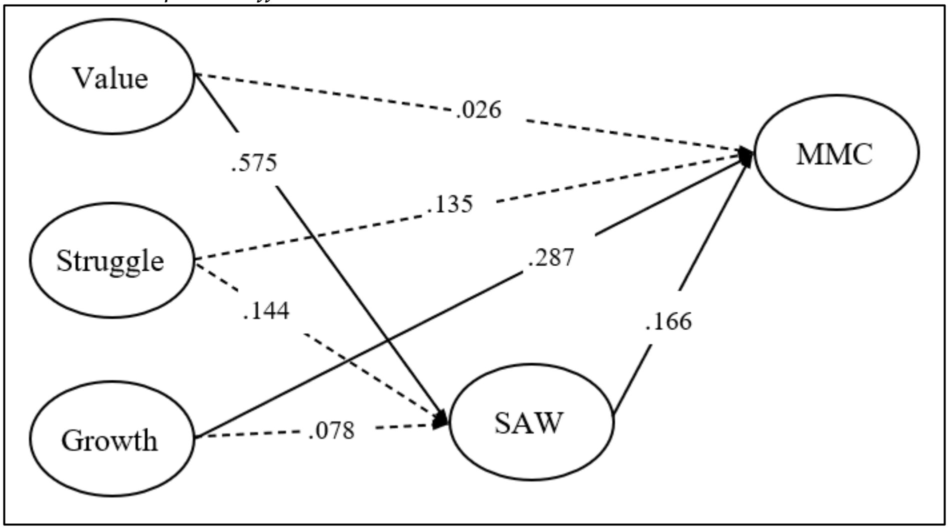
Table 2

Standardized Total, Total Indirect, Specific Indirect, And Direct Effects

Path	Total			Female			Male			
	Est	*S.E.*	*95% CI*	*EST*	*S.E.*	*95% CI*	*EST*	*S.E.*	*95% CI*	*PPC*
Effects from Value to MMC										
Total Effect	0.121	0.065	(−.003, .246)	.148	.074	(−.005, .282)	.104	.120	(−.118, .354)	.312
Indirect Effect										
(Value→ SAW → MMC)	0.095	0.045	(.014, .190)	.160	.059	(.056, .284)	.018	.063	(−.119, .134)	1.645
Direct Effect										
(Value→ MMC)	0.026	0.084	(−.139, .182)	−.012	.093	(−.213, .159)	.086	.145	(−.182, .383)	−.569
Effects from Struggle to MMC										
Total Effect	0.159	0.071	(.017, .300)	.088	.081	(−.065, .249)	.248	.131	(−.030, .489)	−1.039
Indirect Effect										
(Struggle→ SAW → MMC)	0.024	0.017	(−.002, .061)	.003	.031	(−.064, .061)	.010	.036	(−.066, .085)	−.147
Direct Effect										
(Struggle → MMC)	0.135	0.072	(−.007, .279)	.085	.082	(−.066, .257)	.238	.137	(−.047, .491)	−.958
Effects from Growth to MMC										
Total Effect	0.300	0.041	(.220, .379)	.271	.063	(.153, .398)	.364	.056	(.258, .475)	−1.103
Indirect Effect										
(Growth → SAW → MMC)	0.013	0.010	(−.002, .035)	.039	.026	(−.002, .098)	.002	.010	(−.022, .020)	1.328
Direct Effect										
(Growth → MMC)	0.287	0.042	(.205, .369)	.232	.060	(.119, .355)	.363	.058	(.253, .478)	−1.570
Other Direct Effects										
SAW → MMC	.166	.074	(.024, .308)	.285	.092	(.106, .459)	.035	.116	(−.213, .251)	1.689
Value→ SAW	.575	.071	(.439, .718)	.563	.087	(.393, .732)	.510	.132	(.226, .745)	.335
Struggle → SAW	.144	.074	(−.007, .280)	.011	.103	(−.207, .200)	.273	.126	(.035, .538)	−1.610
Growth→ SAW	.078	.046	(−.013, .172)	.136	.077	(−.006, .297)	.055	.063	(−.067, .182)	.814

Note. Est: Standardized Estimate, S.E.: Standard error PPC: Pairwise Parameter Comparisons included as the outcome variable, the path coefficient from growth to MMC was significant for both genders, but the path coefficients from value and struggle were not significant for either gender. Finally, the bootstrap results showed that the indirect effect of value on MMC through SAW was significant for female students, but not for male students, and the indirect effects of growth and struggle on MMC were not significant for either gender. These findings suggest that SAW mediates the relationship between value and MMC for female students, although the differences between male and female students were not statistically significant based on pairwise parameter comparisons.

Figure 1
Standardized path coefficients in the mediation structural model



Note. A solid arrow represents a significant path, and a dashed arrow represents a nonsignificant path; SAW = Subjective Academic Well-Being. MMC = Mathematical Modeling Competency.

5. Discussion

The present cross-sectional study aimed to explore the mediating role of SAW in the relationship between the three dimensions of MR (value, struggle, and growth) and MMC among fifth grade students, as well as the moderating effect of gender on this relationship. The findings obtained from the study first revealed that growth has a significant predictive effect on MMC, while struggle and value do not have a statistically significant direct effect on MMC. Growth refers to the belief that mathematics can be learned by everyone (Kooken et al., 2016). Therefore, the direct effect of growth on MMC may have been significant. This is because students with a high growth mindset have been reported to exhibit higher mathematical performance (OECD, 2021; Yeager & Dweck, 2012). Additionally, MMC can be acquired in well-structured and challenging learning environments where students have developmental opportunities (Wiehe et al., 2025), which also supports the findings of the present study. Furthermore, in the multiple group mediation analysis where gender was used as a moderator, the results indicate that growth is a significant predictor of MMC for both genders, while value and struggle are not significant predictors of MMC for either gender. Moreover, in the present study, the effect of growth on MMC was found to be slightly higher for female students. This finding is consistent with the literature, which suggests that girls are more likely to have a growth mindset (OECD, 2021). Additionally, PISA results for 15-year-old students emphasize a positive relationship between growth mindset and academic performance (OECD, 2021). This finding was similarly observed in the fifth-grade students in the present study. In this regard, the present study contributes to the literature by providing insights into MMC – especially for fifth-grade students– and by offering empirical findings on the role of growth mindset in academic performance in international assessments.

The current study demonstrates that SAW acts as a mediating variable in the relationship between the value dimension of MR and MMC. Well-being is not only about "feeling good and functioning well", but also an optimal functioning state of functioning that arises when students' experiences in the mathematics classroom are in harmony with their personal values (Hill & Seah, 2023). This optimal functioning state may also influence students' academic performance. Research shows that psychologically resilient individuals tend to have high levels of SAW (Arslan et al., 2024), which, in turn, leads to a greater desire to continue attending school (Olsson et al., 2003), and ultimately results in higher academic achievements (Arslan et al., 2024; Yao et al., 2018). This finding is consistent with literature, particularly in the context of mathematics education. On the other hand, it is stated that value is related to achievement (Seah et al., 2022); the current study found that this relationship emerges through SAW as a mediator. Although the direct effect of value on MMC was not significant in the current study, the mediation analysis results showed that the indirect effect of value on MMC through SAW was significant. However, the indirect effects of struggle and growth on MMC through SAW were not significant. This suggests that SAW (a conative variable) acts as a mediating variable between value, a subdimension of MR (an affective variable), and MMC (a cognitive variable). As discussed in the introduction, this result can be considered an important empirical inference that conative variables serve as a bridge between cognitive and affective traits (Seah, 2019). In addition, in the multiple group mediation analysis where gender was used as a moderator, it was found that the indirect effects of value on MMC through SAW were significant for female students, but not for male students. However, the indirect effects of growth and struggle on MMC through SAW were not significant for either gender. This suggests that SAW acts as a mediating variable between value and MMC for female students. The results of the pairwise parameter comparison also show that the difference between males and females is not statistically significant. Additionally, the effect of SAW on MMC is statistically significant for female students, but not for male students. It is stated that gender has a moderating relationship between subjective well-being and achievement (Bücker et al., 2018). In the current study, it was also found that gender has a moderating effect between SAW and MMC. Finally, research on emotions in teaching and learning highlights the significant impact of emotions on educational processes and experiences (Hill et al., 2025). In addition, the current study contributes new empirical insights to the literature regarding the mechanism between SAW, a conative variable, and affective and cognitive traits.

6. Limitations and Implications

The data for this study were collected according to a cross-sectional survey model. As a result, no inferences can be made about the underlying causes of the mechanism between MR, SAW, and MMC. Therefore, longitudinal and experimental studies are needed. First, the current study has revealed that MR, particularly in terms of value, is an important factor affecting students' MMC through SAW. In other words, the MR students possess in relation to value may influence their MMC through SAW, helping them overcome emotional barriers related to mathematics. In this context, further research is needed to investigate the underlying causes of this mechanism. As Lee and Johnston-Wilder (2024b) suggest, teachers can enhance students' learning by considering their well-being and believing that everyone has the potential to improve their understanding. This perspective aligns with the value dimension of MR in the current study. However, in this study, the effect of growth on achievement is observed directly, rather than emerging through SAW. In this regard, similar studies conducted in different cultures could provide more comprehensive insights into whether the effect of growth on achievement influences MMC through SAW or directly. Additionally, while the total effect of struggle is significant, it does not influence MMC, either directly or indirectly. This may be due to the fact that the students in the sample were in 5th grade, and students at this level may not yet recognize that they are struggling with the math learning process (Kooken et al., 2016). As a result, they might have exhibited limited struggle. Since the students in the research group of the current study were taught mathematics in a more concrete manner due to their age, they may not have encountered enough difficulty to require struggle. This could be better understood through expanding the study longitudinally or including students from different grade levels. This way, the role of grade level in the mechanism observed in the current study could be examined in more detail. It is stated that the relationship between academic achievement and subjective well-being may depend on students' educational level (Bücker et al., 2018), and that students' SAW tends to decrease as their grade level increases (Yao et al., 2018). In this regard, in future research where grade level is considered a moderating variable, empirical insights can be gained regarding how the mechanism identified in the current study functions.

Although the current study was conducted specifically in Türkiye, it can also be examined in different countries and cultures. It is stated that there are cultural differences in SAW (Oishi et al., 2021). Thus, the mediating role of well-being, a conative variable, between MR and MMC can provide comprehensive insights that include different cultures and countries. In this way, the knowledge obtained about the mechanisms of interactions between conative, cognitive, and affective characteristics can help us understand the functionality of these characteristics in different cultural contexts. Therefore, by conducting in-depth examinations of groups, organizations, cultures, and systems where people and their well-being are embedded (Lomas et al., 2021), we hope to gain valuable insights for third-wave positive psychology, particularly in the context of mathematics education. Additionally, the current study provides knowledge on the mediating role of conative variables. In future research, comprehensive studies can be conducted that also include the moderating roles of conative variables.

The importance of MR lies in the unique cognitive and affective challenges it presents in mathematical learning. These challenges, when mathematics is taught incorrectly, can lead to anxiety and concern about using mathematics, which can negatively affect individuals' well-being (Lee & Johnston-Wilder, 2024a). In the current study, MMC is considered as cognition, MR as affection, and SAW as cognition (see Introduction), and empirical findings regarding the mechanism between these variables have been obtained. In future research, experimental studies supporting MR or mathematical well-being can be conducted to more thoroughly explore their roles in the learning process.

This study has revealed that valuing mathematics affects MMC through SAW. However, in the current study, value has been generally considered as a subdimension of MR. In contrast, mathematical values are a concept that consists of several dimensions, which may vary depending on the culture (Hill & Seah, 2023). In this regard, if the current study is repeated considering the subdimensions of mathematical values, more detailed findings could be obtained. Moreover, the aspects students value in different disciplines may differ from those in mathematics, and as a result, their well-being may also differ (Hill & Seah, 2023). Therefore, the mechanism addressed in this study could be expanded to include different disciplines. In this way, significant contributions to the literature could be made regarding how the mechanism identified in the current study functions across various disciplines.

Overall, the results of this study contain important implications for teachers and policymakers regarding the development of students' MMC. This study, by considering the moderating role of gender, reveals the mechanism between MR, SAW, and MMC, offering practical insights into how students' MMC can be enhanced. The empirical evidence presented in this study regarding the mechanism between affective, conative, and cognitive variables makes a significant contribution to the literature. In this regard, this study offers practical implications for educators or researchers who aim to enhance students' MMC. For instance, based on the results of the current study, teachers can create a positive learning environment that gives the best chance to increase MMC by maintaining students' well-being through pedagogical choices (Lee & Johnston-Wilder, 2024a). In other words, making pedagogical decisions that foster a positive learning environment, support everyone's well-being, and provide the best opportunities for success as healthy mathematics students can improve students' MMC. Additionally, when people perceive mathematics as irrelevant to their daily lives or to something personally meaningful, they may struggle to value mathematics (Lee & Johnston-Wilder, 2017). Therefore, students' values can be raised by relating mathematics to daily life (Borromeo-Ferri, 2018; Cevikbas et al., 2025; Geiger et al., 2025), or their well-being can be improved by creating an encouraging and inclusive environment in their interactions with teachers, other students, and educators (Lee & Johnston-Wilder, 2024b).

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