LATENT PROFILES OF MATHEMATICAL RESILIENCE AND THEIR RELATIONSHIP WITH ACADEMIC ACHIEVEMENT IN MIDDLE SCHOOL STUDENTS: A PERSON-CENTRED APPROACH

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This study adopted a person-centred approach to identify latent profiles of mathematical resilience among 815 middle school students (Grades 5-8) and examine differences in academic achievement across profiles. Latent profile analysis revealed three profiles: Fully Resilient, Persistent but Growth-Deficient, and Moderate Resilience. Students in the Fully Resilient profile demonstrated significantly higher achievement than the other profiles, with no significant difference between Persistent but Growth-Deficient and Moderate Resilience profiles. These findings highlight the multidimensional nature of mathematical resilience and underscore the critical role of growth-oriented beliefs in translating persistence into success. Educational interventions should be tailored to resilience profiles, emphasizing growth beliefs.

INTRODUCTION

Positive psychology focuses on understanding individuals' strengths and capacities that contribute to optimal functioning and well-being (Seligman, 2011). One of the core components of this discipline, psychological resilience (Wong, 2011), is defined as individuals' capacity to overcome the challenges they encounter and refers to the ability to achieve optimal adaptation despite adverse conditions (Vera Gil, 2024).In educational contexts, and particularly in mathematics learning, this construct has been operationalized as mathematical resilience, reflecting students' capacity to cope with obstacles, errors, and setbacks inherent in learning mathematics while sustaining a positive orientation toward the subject (Lee & Johnston-Wilder, 2014). Conceptually, mathematical resilience comprises three interrelated dimensions: value, struggle, and growth (Kooken et al., 2016). The value dimension reflects students' perceptions of mathematics as meaningful and useful for present and future goals. The struggle dimension captures perseverance and effort when encountering mathematical difficulty, while the growth dimension represents the belief that mathematical ability is malleable and can be developed through learning rather than being determined by innate talent. Together, these dimensions describe how students interpret, respond to, and persist through mathematical challenges. Existing research has examined mathematical resilience in relation to instructional practices, resilience coaching, and a range of cognitive and affective variables. For example, resilience-oriented coaching has been shown to reduce mathematics anxiety and support students in overcoming

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learning barriers (Lee & Johnston-Wilder, 2014), and the development of valid and reliable measurement tools has strengthened empirical research in this area (Kooken et al., 2016). Classroom-based studies further indicate that integrating principles of mathematical resilience into instruction positively influences students' learning processes and engagement (Lee & Ward-Penny, 2022). More recent studies have investigated mathematical resilience within mediation and moderation frameworks, linking it to constructs such as self-efficacy, metacognition, motivation, psychological resilience, mathematics anxiety, and academic achievement (Agtarap & Miranda, 2022; Demir, 2023; Gürefe & Eryılmaz, 2025; Turgut & Uğurlu, 2024; Zengin & Akcakin, 2025). Despite this growing body of research, most studies have adopted variable-centred approaches that rely on overall mathematical resilience scores, implicitly assuming homogeneity among students. Such approaches overlook the possibility that students may exhibit distinct combinations of value, struggle, and growth beliefs. Given the multidimensional nature of mathematical resilience, it is likely that heterogeneous profiles exist, reflecting qualitatively different ways in which students engage with mathematical challenges. However, empirical evidence identifying these latent profiles and examining their association with academic outcomes remains limited, particularly at the middle school level. Addressing this gap, the present study adopts a person-centred approach to identify latent profiles of mathematical resilience among middle school students based on their value, struggle, and growth scores. In addition, the study examines whether these profiles differ in terms of academic achievement, thereby providing a more nuanced understanding of how distinct patterns of mathematical resilience are associated with academic outcomes. The following two research questions guided this investigation:

1. What latent profiles of mathematical resilience can be identified among middle school students based on their scores on the value, struggle, and growth dimensions of the mathematical resilience questionnaire?

2. Do the identified latent profiles differ in students' academic achievement?

METHOD

Research design

This study employed a descriptive–relational research design and utilized Latent Profile Analysis (LPA) to examine patterns in middle school students' mathematical resilience. This design enables the identification of naturally occurring subgroups by describing relationships among variables and capturing individual differences within the population. Unlike predictive or causal research designs, the primary aim of this study was not to predict outcomes but to investigate how factors underlying mathematical resilience cluster to form distinct profiles during the middle school period, thereby revealing heterogeneity within the population. In this context, LPA was selected as a person-centred statistical approach that classifies individuals into latent profiles based on their response patterns to observed indicators. By focusing on

individual-level variability, LPA facilitates a more nuanced and multidimensional examination of the developmental aspects of mathematical resilience (Collins & Lanza, 2010). Without testing causal relationships, this approach yields descriptive and informative findings that may inform educational practices and the design of targeted intervention programs.

Participant

The participants of the study consisted of 815 middle school students enrolled in Grades 5 through 8. Of the total sample, 454 students (55.7%) were female and 361 students (44.3%) were male. With respect to grade level, 201 students (24.7%) were in Grade 5, 203 students (24.9%) were in Grade 6, 212 students (26.0%) were in Grade 7, and 199 students (24.4%) were in Grade 8. Overall, the sample included students from all middle school grade levels with a relatively balanced distribution across grades, while the proportion of female students was slightly higher than that of male students.

Measure

The Mathematical Resilience Questionnaire (Kooken et al., 2016) includes 24 items across three dimensions: value, struggle, and growth, rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Higher scores indicate greater resilience and a stronger growth mindset. Following psychometric evaluation (Zengin & Akcakin, 2025), five items with low factor loadings were removed, leaving 19 items. Confirmatory factor analysis (CFA) supported the three-factor structure for middle school students (factor loadings: .33–.81; CFI = .91; RMSEA = .056; SRMR = .058), and reliability was good (Cronbach's α = .83), indicating the scale is valid and reliable for this population.

Data Analysis

Latent profile analysis (LPA) was conducted using students' scores on the value, struggle, and growth dimensions to identify distinct profiles of mathematical resilience. Model selection was based on multiple fit indices—including Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), sample-size adjusted BIC (ABIC), entropy, Lo–Mendell–Rubin likelihood ratio test (LMR), adjusted LMR (ALMR)—as well as theoretical interpretability of the profiles. To examine differences in academic achievement across profiles, a one-way ANOVA was conducted, followed by Bonferroni-adjusted post-hoc comparisons.

RESULTS

Model Fit Indices and Latent Profile Selection

Model fit statistics for latent profile solutions ranging from one to five classes are summarized in Table 1. The AIC, BIC, and ABIC values decreased as the number of latent classes increased, indicating improved model fit with additional profiles. Entropy values, reflecting classification accuracy, were highest for the three-class

solution (0.933), suggesting optimal separation among latent profiles. Visual inspection of the AIC, BIC, and ABIC plots further revealed a noticeable flattening of the curves after the three-class solution, indicating diminishing improvements in model fit with the addition of further classes.

LMR and ALMR tests indicated that the two-class solution provided a significantly better fit than the one-class model ($p < .01$). The comparison between the three- and two-class solutions was not statistically significant (LMR $p = .0876$; ALMR $p = .0886$), suggesting that the addition of a third class did not result in a statistically significant improvement in model fit. Although the four-class solution showed a significant improvement over the three-class model ($p = .001$), this solution was associated with lower entropy and reduced parsimony. The five-class solution did not yield a significant improvement over the four-class model.

Considering statistical fit indices, classification accuracy, model parsimony, and theoretical interpretability, the three-class solution was selected as the optimal model. This solution demonstrated the highest entropy and provided meaningful and theoretically coherent latent profiles.

Table 1: Model fit indices for latent profile solutions

Model	AIC	BIC	ABIC	Entropy	LMR	ALMR
One-class	35787	35966	35845	–	–	–
Two-class	33021	33294	33109	.897	< .01	< .01
Three-class	26791	27336	26968	.933	.0876	.0886
Four-class	26470	27199	26707	.880	.0010	.0011
Five-class	26260	27173	26557	.870	.6437	.6448

Latent Profiles of Mathematical Resilience

Latent Profile Analysis (LPA) was conducted to examine distinct patterns of mathematical resilience among middle school students. Based on responses to the value, struggle, and growth dimensions of the Mathematical Resilience (MR) scale, three profiles emerged: Profile 1 (Fully Resilient, $n = 462$) included students who scored high across all dimensions, indicating strong overall mathematical resilience and a growth-oriented mindset; Profile 2 (Persistent but Growth-Deficient, $n = 155$) comprised students with high value and struggle but lower growth scores, suggesting persistence and recognition of mathematics' importance alongside weaker growth mindset orientation; and Profile 3 (Moderate Resilience, $n = 198$) consisted of students with moderate scores across all dimensions, reflecting average mathematical resilience.

Table 2 presents the distribution of students across grades for each profile. Profile 1 (Fully Resilient) was the largest group, followed by Profile 3 (Moderate Resilience)

and Profile 2 (Persistent but Growth-Deficient). The distribution across grades remained relatively consistent, suggesting that these resilience patterns are stable throughout the middle school period.

Table 2: Distribution of mathematical resilience profiles across grade levels

Profile	Grade 5	Grade 6	Grade 7	Grade 8
Profile 1 (Fully Resilient)	130 (28.1%)	108 (23.4%)	122 (26.4%)	102 (22.1%)
Profile 2 (Persistent but Growth-Deficient)	37 (23.9%)	46 (29.7%)	35 (22.6%)	37 (23.9%)
Profile 3 (Moderate Resilience)	34 (17.2%)	49 (24.7%)	55 (27.8%)	60 (30.3%)
Total	201 (24.7%)	203 (24.9%)	212 (26.0%)	199 (24.4%)

Differences in Academic Achievement

A one-way analysis of variance (ANOVA) was conducted to examine differences in academic achievement across the three mathematical resilience profiles (see Table 3). The results indicated a significant effect of profile membership on achievement, F (2, 812) = 17.73, $p < .001$, $\eta^2 = .042$. Bonferroni-adjusted post hoc comparisons revealed that students in Profile 1 (Fully Resilient) achieved significantly higher school scores than students in Profile 2 (Persistent but Growth-Deficient) and Profile 3 (Moderate Resilience). However, no statistically significant difference was found between Profile 2 and Profile 3. These findings suggest that while high levels of value and struggle are important, the presence of a strong growth dimension appears to be critical for attaining the highest levels of academic achievement.

Table 3: Descriptive statistics for academic achievement by mathematical resilience profiles

Profile (Style)	N	M	SD	95% CI
Profile 1 (Fully Resilient)	462	75.10	22.36	72.87, 77.33
Profile 2 (Persistent but Growth-Deficient)	155	66.72	24.15	62.87, 70.57
Profile 3 (Moderate Resilience)	198	63.70	28.74	60.30, 67.11

DISCUSSION

The present study adopted a person-centred approach to examine heterogeneity in middle school students' mathematical resilience and its association with academic achievement. Latent profile analysis identified three distinct profiles characterized by different configurations of value, struggle, and growth dimensions. The findings extend previous variable-centred research by demonstrating that mathematical resilience is not a uniform construct across students but rather manifests in qualitatively different patterns that are meaningfully related to academic achievement.

Students classified in Profile 1 (Fully Resilient) exhibited high levels across all three dimensions of mathematical resilience and achieved significantly higher academic outcomes than students in the other profiles. This result aligns with theoretical perspectives emphasizing the synergistic role of valuing mathematics, persisting through difficulty, and endorsing growth-oriented beliefs in supporting adaptive learning behaviours (Kooken et al., 2016). Importantly, the findings suggest that growth beliefs may play a facilitative role in translating effort and value into academic success. Several explanatory pathways are plausible. Students with growth-oriented beliefs may interpret challenges differently than those with more fixed mindsets—viewing difficulties as informative rather than threatening (Dweck, 2006). Such beliefs may also support adaptive responses to setbacks, including strategic help-seeking and persistence through trial and error. These processes could explain why the Persistent but Growth-Deficient profile, despite high value and struggle, did not demonstrate superior achievement compared to the Moderate Resilience profile. However, the present study's correlational design does not permit strong causal claims, and future research employing experimental or longitudinal methods is needed to test these proposed mechanisms directly.

Profile 2 (Persistent but Growth-Deficient) represents a particularly informative subgroup. Although students in this profile reported high levels of value and struggle, their comparatively lower growth scores were associated with reduced academic achievement relative to Profile 1. This pattern indicates that persistence and valuing mathematics alone may be insufficient for optimal performance when students lack strong beliefs about the malleability of mathematical ability. In line with prior research on growth mindset and resilience, these students may exert effort but interpret setbacks in ways that undermine learning efficiency or strategic engagement (Lee & Johnston-Wilder, 2017). This finding highlights the importance of examining combinations of resilience dimensions rather than relying on overall resilience scores.

Students in Profile 3 (Moderate Resilience) demonstrated average levels of mathematical resilience and the lowest achievement outcomes among the three profiles. This profile may reflect students who neither strongly disengage from mathematics nor actively mobilize adaptive coping strategies when encountering difficulty. From a developmental perspective, these students may be particularly sensitive to instructional context and could benefit from targeted support designed to

strengthen multiple dimensions of resilience simultaneously. Overall, the results underscore the value of person-centred methodologies in mathematics education research. By revealing distinct resilience profiles, the present study offers a more nuanced understanding of how affective and motivational factors co-occur within individuals and relate to academic outcomes. Such insights are difficult to obtain through traditional variable-centred approaches that assume population homogeneity.

Limitations and Implications

Several limitations warrant consideration. First, the cross-sectional design limits causal inferences; longitudinal research is needed to examine profile stability and directionality of effects. Second, school grades may reflect factors beyond mathematical competence; future studies should incorporate standardized measures. Finally, the mechanisms linking growth beliefs to achievement require further investigation through qualitative or mixed methods approaches.

CONCLUSION

This study examined middle school students' mathematical resilience profiles and their relationship with academic achievement. Using students' scores on the value, struggle, and growth dimensions, Latent Profile Analysis identified three profiles: Fully Resilient (high on all dimensions), Persistent but Growth-Deficient (high value and struggle, low growth), and Moderate Resilience (average on all dimensions). Analyses showed that students high on all three dimensions achieved significantly higher academic outcomes than the other groups, indicating that valuing mathematics and perseverance alone are not sufficient for top performance. The findings highlight that mathematical resilience is multidimensional and heterogeneous, and educational interventions should be tailored to students' resilience profiles, with particular emphasis on fostering growth-oriented beliefs.

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