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Why some students excel in mathematics: growth mindset, intrinsic motivation, and school autonomy in top-performing Asian and Western economies

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Abstract
Mathematical proficiency in adolescence is crucial for both individual success and national economic development; yet few studies have examined cross-national differences in how achievement-related beliefs, motivations, and institutional factors affect mathematical outcomes. Specifically, this study filled the gap by investigating the impact of growth mindset, intrinsic motivation, and school autonomy on students' mathematics performance across five top-performing Asian (Singapore, Macao, Hong Kong, Taipei, and Korea) and five top-performing Western (Switzerland, Ireland, Denmark, the United Kingdom, and Poland) education systems. We used the Programme for International Student Assessment 2022 dataset (N = 66,789) and multilevel mediation analyses to reveal that (a) growth mindset was positively associated with mathematics performance in all five Western economies and two Asian economies (Singapore and Taipei). (b) Intrinsic motivation mediated the pathway from growth mindset to mathematics performance in four Western economies (Ireland, Denmark, the United Kingdom, and Poland) and all five Asian economies. (c) School autonomy exhibited context-dependent moderating effects, strengthening the influence of growth mindset in Korea while amplifying the association between intrinsic motivation and mathematics performance in Singapore. This study highlights the importance of aligning educational interventions that target students' motivational beliefs with the cultural and institutional contexts in which they are implemented.

Keywords Growth mindset, Intrinsic motivation, School autonomy, Mathematics achievement

Introduction

With technological advancements, strong mathematics performance among young people is crucial for both individual career readiness and long-term national economic development. For adolescents, mathematical skills are consistently linked to higher wages and lower unemployment rates, regardless of their educational attainment (Kane

et al., 2022; Koedel & Tyhurst, 2012; Watts, 2020). For a nation, mathematics is central to technological innovation and economic growth, especially in fields such as data science and artificial intelligence, which drive modern economies (OECD, 2024a). A recent panel study of 78 countries (2012–2018) demonstrated that mathematics showed the strongest positive impact among all academic domains on economic development and innovation capacity (Hanushek & Woessmann, 2008; Naveed et al., 2023). However, the Programme for International Student Assessment (PISA) has consistently reported significant variations in mathematics achievement across countries, with East Asian educational systems such as Singapore, Hong Kong, and South Korea often leading in mathematics performance, outperforming most Western economies. However, the underlying psychological and institutional mechanisms remain contested (von Davier et al., 2024).

Importantly, growth mindset and intrinsic motivation have been shown to have a strong association with academic outcomes (Boncquet et al., 2023; Sisk et al., 2018), but the associations vary across cultural contexts. Specifically, East Asian systems tend to emphasize effort, diligence, and perseverance, while Western countries place greater importance on fostering students' interest, growth mindset, and critical thinking, which support self-driven motivation and engagement in learning (Farzan, 2018; Lee, 2014). For instance, intrinsic motivation in mathematics is positively associated with achievement in Finland and Denmark, whereas in Confucian heritage cultures such as Singapore and Korea, students' mathematics achievement is more closely linked to extrinsic motivation, driven by parental expectations and the pursuit of social recognition and honor (Niu et al., 2025).

Self-determination theory (SDT) suggests that individuals are more likely to engage in activities they find inherently enjoyable as they interact with their environments, and they tend to achieve greater creativity and productivity when intrinsically motivated (Ryan & Deci, 2000). In educational contexts, students' academic performance may therefore be either enhanced or constrained by the ways in which external contexts operate (Cook & Artino, 2016). Based on this theory, school autonomy is an important contextual factor that shapes the quality of the school environment, such as school climate and teacher-student relationships, which may in turn influence students' motivation and learning dispositions (Carmichael et al., 2017; Khanal & Guha, 2023). Researchers have noted that school autonomy has a significant influence on students' academic performance, although this relationship is complex and context-dependent (Buerger et al., 2023). Very few studies have examined how the degree of school autonomy influences or interacts with students' motivational beliefs and learning dispositions across different countries.

While school autonomy influences students' learning outcomes within the school environment, the impact may vary across countries depending on the broader cultural values and norms in which schools are embedded. Varied mathematics performance across countries can be partly attributed to contrasting educational values rooted in distinct cultural traditions. Research analysing data from 51 countries found that national culture significantly influences mathematics achievement, accounting for approximately 23.89% of the variance between countries (Hu et al., 2018). Compared to Western cultures, East Asian regions influenced by Confucian heritage culture view hard work and effort as central to students' academic identity (Liman et al., 2023). For example, although Korean students consistently achieve high mathematics scores, they often

report lower levels of confidence and interest in mathematics compared to their peers in Western countries, reflecting a value system that prioritizes effort over enjoyment (Pang & Seah, 2021).

In addition, persistent gender and socioeconomic disparities continue to shape students' mathematics outcomes. On average, 15-year-old boys outperform girls in mathematics by approximately 9% across OECD economies (OECD, 2023a; Wang et al., 2023). Students from disadvantaged socioeconomic backgrounds generally exhibit lower engagement and interest in mathematics compared to their more affluent peers (Ersan & Rodriguez, 2020; Wang et al., 2023). Therefore, the present study investigates how students' motivational beliefs (growth mindset and intrinsic motivation) and school autonomy influence their mathematics achievement across ten top-performing Asian (Singapore, Macao, Hong Kong, Taipei, and Korea) and Western educational systems (Switzerland, Ireland, Denmark, the United Kingdom and Poland), while controlling for gender, socioeconomic status (SES), and learning effort.

Growth mindset and mathematics performance

Dweck (2008) conceptualized intelligence as existing along a continuum between two belief systems: the entity theory, which views intelligence as a fixed trait, and the incremental theory, which assumes that intelligence can be developed through effort and learning (a growth mindset). Students with a growth mindset are more likely to embrace challenges as opportunities for development, set mastery goals, and respond to failure by adjusting their strategies rather than withdrawing (Dweck, 1999). In contrast, individuals with a fixed mindset often exhibit a helpless orientation when confronted with difficulty, as they interpret struggle as evidence of low ability (Montgomery et al., 2023). In educational settings, high performers tend to take a greater role in shaping their experiences and focus on mastery rather than merely proving ability (Landoll et al., 2021).

From the perspective of SDT, the mastery-oriented belief corresponds closely with the psychological need for competence, defined as the innate desire to feel effective, capable, and successful when interacting with the environment (Ryan & Deci, 2017). Competence represents a fundamental psychological need that underpins intrinsic motivation (Huang, 2025). Students can experience competence by mastering a difficult task, improving through practice, or receiving positive feedback, and then they can gain a sense of effectiveness that validates their belief in personal growth (Johnston-Wilder et al., 2021; Wang et al., 2022). Empirical research also shows that a growth mindset is positively associated with perceived competence (Dutt et al., 2023). When students hold a growth mindset, they are more likely to interpret academic challenges and failures as constructive information that helps them refine their strategies, thereby reinforcing their sense of competence. In other words, students begin to engage in learning not merely to prove ability but because the process of improvement itself becomes inherently satisfying.

Empirical studies have shown that a growth mindset is positively associated with academic performance, particularly in mathematics (Yeager et al., 2019). Growth-minded students tend to show greater resilience and persistence, leading to more favourable learning outcomes. Furthermore, many studies have found a positive relationship between growth mindset and academic performance across different countries and cultural backgrounds (O'Keefe et al., 2023; Sriutaisuk et al., 2024; van Hoeve et al., 2023).

Nevertheless, the association between growth mindset and mathematics performance is positive but modest, with variation across different cultures.

In some educational contexts, particularly East Asian systems that emphasize diligence and achievement, students with fixed beliefs may still sustain effort due to external pressures and instrumental motivations (Boncquet et al., 2023; Dong & Kang, 2022). In such contexts, societal expectations and institutional policies may sustain students' effort and academic achievement despite the absence of a growth mindset (Liman et al., 2023; Pang & Seah, 2021). While in the western educational system, students with a growth mindset tend to attribute failures to controllable factors and focus on self-improvement to achieve better academic outcomes (Stohlmann & Yang, 2024; Zeeshan, 2025). Although the importance of a growth mindset in educational settings is well recognized, how students internalize this belief may vary considerably across countries. Understanding these cross-cultural differences is essential for designing and implementing effective and contextually relevant growth mindset interventions that support students' motivation and learning in diverse educational systems.

Intrinsic motivation as a mediator

SDT posits that the interplay between individual psychological processes and environmental conditions drives various forms of human motivation and behavior. Within this framework, intrinsic motivation, defined as personal engagement driven by interest, enjoyment, or perceived importance, is positively linked to persistence, effective learning strategies, and deeper understanding. In contrast, extrinsic motivation is primarily influenced by rewards or the avoidance of punishment (Irvine, 2018).

A central process in SDT is internalization, which describes how externally regulated motivations can be gradually transformed into more autonomous forms when they are personally endorsed and integrated into the self. Cognitive evaluation theory, a subtheory of SDT, explains that this internalization is facilitated by the fulfilment of three basic psychological needs: autonomy, competence, and relatedness (Cook & Artino, 2016). Motivation, therefore, is not a static trait but a dynamic process that can evolve over time. Through internalization, extrinsic motivation can gradually transform into intrinsic motivation when external goals are personally endorsed and integrated into the self (Irvine, 2018). The degree of internalization and integration determines the extent to which intrinsic motivation can effectively sustain students' engagement and achievement in mathematics (Wang et al., 2022). Consistent with this view, Ryan and Deci (2022) argue that more internalized forms of motivation are associated with more positive performance outcomes than externally regulated forms.

Building on SDT, previous research has emphasized the link between intrinsic motivation and growth mindset in relation to learning outcomes (Cook & Artino, 2016). Students with a growth mindset demonstrate higher intrinsic motivation and greater persistence when facing academic challenges, as they perceive effort and difficulty as opportunities for learning (Dweck & Leggett, 1988; Karlen et al., 2019; Renaud-Dubé et al., 2015). Students who adopt mastery-oriented goals that emphasize self-improvement rather than outperforming others tend to display stronger intrinsic motivation and more adaptive learning behaviors (Altikulaç et al., 2024). Conversely, students with a fixed mindset may experience reduced intrinsic motivation in contexts that threaten their self-concept as "naturally capable", that is, when their sense of competence is grounded

in the belief that intellectual ability is an inherent and stable trait rather than a quality that can be developed through effort (Yeager & Dweck, 2020). In a recent study, Jumangit and Miranda (2025) found that a growth mindset had both a direct positive effect on mathematics grades and an indirect effect via student motivation. Similarly, Dong et al. (2023) reported that intrinsic motivation mediated the relationship between growth mindset and mathematics performance among Chinese students. These findings suggest that a growth mindset influences academic achievement not only directly, but also indirectly by fostering intrinsic motivation.

Furthermore, cultural context plays a crucial role in shaping how individuals internalize mindset-related beliefs, which lead to different academic outcomes. In Western educational systems, students are more likely to pursue learning out of autonomous interest, while in East Asian systems, intrinsic motivation often emerges when students come to value learning for its own sake (Xu, 2020). For instance, students who have higher intrinsic motivation tend to achieve better mathematics outcomes in German elementary schools (Farzan, 2018). Similarly, mastery-goal orientations have been shown to enhance Singaporean students' academic achievement through increased intrinsic motivation (Lay & Chandrasegaran, 2016; Liu, 2021).

In sum, understanding how intrinsic motivation functions as a mediating mechanism between growth mindset and mathematics achievement across different cultural contexts is essential for explaining the varied effects of growth mindset. It also helps identify conditions that promote sustained and self-determined learning, particularly when comparing top-performing Asian and Western economies. Accordingly, this study hypothesises that a growth mindset enhances mathematics performance through intrinsic motivation, and that this mechanism may be especially pronounced in East Asian educational contexts.

School autonomy as a moderator

School autonomy refers to the authority that school managers hold over planning, operations, and policies, which is influenced by the level of decentralization in an education system. It typically includes decision-making in three key areas: administrative management, resource allocation, and the educational framework (Buerger et al., 2023; OECD, 2023b). A lower average level of school autonomy reflects a more centralized or hierarchically governed education system, where schools may have limited decision-making power (Lastra-Anadón & Mukherjee, 2019). SDT proposes that when students' basic psychological needs—autonomy, competence, and relatedness are supported, they are more likely to internalize external goals and develop more autonomous forms of motivation (Deci & Ryan, 2000; Ryan & Deci, 2017). Institutional autonomy at the school level can enable teachers to engage in these autonomy-supportive behaviors, as greater school-level flexibility allows for more adaptive pedagogical decisions and innovations in classroom practice (Assor et al., 2002). In this way, school autonomy may translate into autonomy-supportive classroom climates that facilitate deeper internalization and foster sustained intrinsic motivation among students.

The relationship between school autonomy and students' mathematics performance varies across different countries (OECD, 2011). Evidence suggests that school autonomy tends to improve mathematics achievement in developed and high-performing countries but may have mixed effects in less-developed countries (Hanushek et al., 2013). In

PISA 2022, students demonstrate high mathematics performance not only in developed countries such as the UK, Denmark, and Sweden, but also in some less-developed economies. This suggests that national development alone cannot explain the influence of school autonomy. Rather, its effect appears to depend on school-level conditions, including leadership quality and the balance between autonomy and accountability, which vary considerably across schools and countries (Buerger et al., 2023).

At the school level, granting schools greater institutional autonomy has been shown to foster more motivationally supportive practices and positive learning environment, which may moderate the relationship between students' motivation, growth mindsets, and mathematics performance (Carmichael et al., 2017; Jackson, 2023; Soe et al., 2025). Cross-national evidence reinforces the importance of modeling school autonomy as a moderator. For example, a national study in Australia has shown that autonomy-rich environments encourage students' mastery goal orientations, thereby buffering the negative effects of a fixed mindset on learning outcomes (Carmichael et al., 2017). Likewise, a recent analysis of a Chicago Reform has reported that giving school principals more control over budgeting and operations is related to improved mathematics achievement, better school climate, and increased student effort in autonomy-granted schools (Jackson, 2023). In Myanmar, similarly, an autonomy-supportive environment is associated with greater intrinsic motivation and mathematics achievement (Soe et al., 2025).

Together, previous research has largely focused on the direct relationship between school autonomy and students' motivational factors and academic achievement within a particular national setting. Hence, it is necessary to extend prior research by investigating school autonomy as a contextual moderator of mathematics performance across different Western and Asian top-performing economies to get a deep understanding of the impact of school autonomy.

The present study

Given the research gaps, the present study investigates the relationship between growth mindset and intrinsic motivation (as student-level characteristics) and their impact on students' mathematics performance. It also examines how school autonomy, as a school-level contextual factor, moderates this pathway across different educational systems and cultural contexts (see Fig. 1). Drawing on SDT and previous studies, this study hypothesizes that a growth mindset can positively influence students' mathematics achievements, with intrinsic motivation mediating this relationship. This pathway may function differently across various cultural settings. Furthermore, school autonomy is expected to moderate this pathway, with its influences varying across top-performing Asian and Western economies. Given the persistent disparities in gender, SES, and learning effort, these factors were included as control variables in the analysis (Ersan & Rodriguez, 2020; OECD, 2023a; Wang et al., 2023). Based on the conceptual model in Fig. 1, we propose the following research questions:

RQ1: How does a growth mindset influence adolescents' mathematics performance in top-performing Asian and Western economies?

RQ2: What is the mediating role of intrinsic motivation in the relationship between growth mindset and mathematics performance across different cultural contexts?

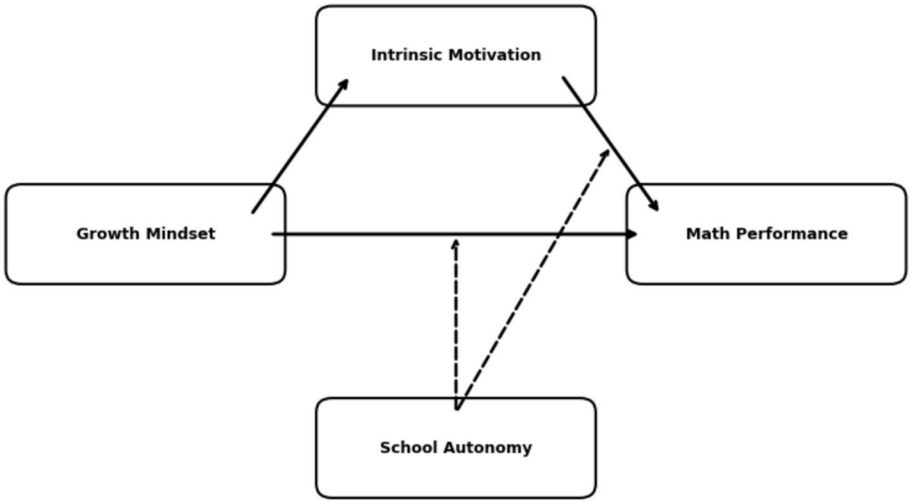

Fig. 1 Conceptual model of factors affecting mathematics performance

RQ3: How does school autonomy moderate the relationship between students' motivational beliefs (growth mindset and intrinsic motivation) and mathematics achievement across different cultural contexts?

Method

Participants

This study utilized data from the large-scale PISA project conducted by the Organisation for Economic Co-operation and Development (OECD). PISA employs a two-stage stratified sampling procedure to select representative samples of 15-year-old students and assesses their knowledge and skills in reading, mathematics, and science. The goal is to generate internationally comparable data to evaluate the effectiveness of education systems across countries. The assessment is administered every three years, with each cycle designating one of the three domains as the major focus (OECD, 2023a, 2024b). In PISA 2022, approximately 700,000 students from 81 countries and economies participated, with mathematics designated as the major domain.

For the purpose of cross-cultural comparison, the present study selected the top ten economies ranked highest in mathematics scores in PISA 2022, including five Asian and five Western economies. Japan was excluded from the Asian group due to missing data on intrinsic motivation, and Estonia, Canada, the Netherlands, and Belgium were excluded from the Western group due to incomplete data on school autonomy. The final sample consisted of the following economies:

Asian economies: Singapore (N = 6606), Macao [China] (N = 4384), Chinese Taipei (N = 5857), Hong Kong [China] (N = 5907), and Korea (N = 6454);

Western economies: Switzerland (N = 6829), Ireland (N = 5569), Denmark (N = 6200), the United Kingdom (N = 12,972), and Poland (N = 6011).

As the dataset is publicly available and fully anonymized, ethical approval was overseen by National Research Coordinators in each participating country in accordance with local regulations.

Measures

Growth mindset. Students responded on a 4-point scale from 1 (strongly disagree) to 4 (strongly agree) how much they agreed with "Your intelligence is something about you that you can't change very much." We reversed the score so that higher values indicate a stronger growth (as opposed to fixed) mindset. A previous study using a single-item measure of growth mindset demonstrated moderate test–retest reliability (Rammstedt et al., 2024).

Intrinsic Motivation. Students reported the degree to which they enjoyed learning and engagement with challenging schoolwork. The items included: "I like to ask questions," "I love learning new things in school," "I like to develop hypotheses and check them based on what I observe," "I enjoy thinking about new ways to solve problems," and "I like schoolwork that is challenging." Participants responded on a Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The one-factor confirmatory factor analysis model was acceptable for these five items across 10 economies (CFI = .85–.86, RMSEA = .04–.08, SRMR < .08; see Online Appendix B). The internal consistency (Cronbach's α) of the intrinsic motivation across all economies is 0.74. A high score indicated higher interest and enjoyment in mathematics.

School Autonomy. Principals were asked about who had the main responsibility for various decisions or activities at their school (12 items, e.g., "Appointing or hiring teachers", "Determining teachers' salary increases"). There were six response categories: "Principal", "Teachers or members of school management team", "School governing board", "Local or municipal authority", "Regional or state authority", and "National or federal authority". In the analyses, higher values on the weighted likelihood estimated (WLE) scores indicate a higher level of autonomy in decision-making activities at their school.

Control Variables. Binary gender (female = 0, male = 1), socioeconomic status (SES), and learning effort were included as control variables. Socioeconomic status was measured using the Economic, Social, and Cultural Status (ESCS) index provided in PISA 2022. Learning effort was assessed through students' self-reported frequency of effortful learning behaviors in mathematics (e.g., "I put effort into my assignments for mathematics class") on a five-point Likert scale ranging from "Never or almost never" to "All or almost all of the time". Higher values of the WLE scores indicate that students demonstrate more proactive mathematics study behavior.

Mathematics performance. The dependent variable reflects 15-year-old students' ability to use mathematics to solve real-world problems. It assesses how well students can formulate, apply, and interpret mathematics in a variety of contexts. Because students completed different subsets of test items rather than the entire test, PISA estimated proficiency using 10 plausible values per student (OECD, 2024b). The scaling method employed in PISA analyses, known as population modeling, combines Item Response Theory with latent regression to improve measurement precision and reduce bias across economies (OECD, 2024b). Detailed descriptions of all measures and variables are provided in Online Appendix A.

Data analyses

To obtain unbiased population estimates, the final student weights variable and school weights variable were used. Missing data for SES (4.6%), mindset (7.5%), intrinsic motivation (7.8%), school autonomy (10.8%), and learning effort (11.2%) across all economies

were addressed using multiple imputation, yielding 10 datasets for each country. The results of 10 imputed datasets were integrated with Rubin's rules using Mplus 8.11 (Muthén & Muthén, 2017).

Following imputation, descriptive and correlational analyses were conducted for each country. A null model was then estimated to disaggregate the variance in students' intrinsic motivation and mathematics performance into student-level and school-level components, yielding intraclass correlation coefficients (ICCs) for both outcomes across economies.

To account for the nested structure of the PISA 2022 data, students (Level 1) nested within schools (Level 2), and schools nested within economies (Level 3), a multilevel mediation analysis was conducted. This approach explicitly models within- and between-cluster variance, allowing more accurate parameter estimates and standard errors for the data with nested structures (Ryu & West, 2009). The analyses were conducted separately for each country. Specifically, each model tested whether the relationship between growth mindset and mathematics performance was mediated by intrinsic motivation while controlling for SES, gender, and learning effort. Additionally, cross-level interaction terms were included to assess whether school autonomy moderated the relationship between growth mindset, intrinsic motivation, and students' mathematics performance. All models were estimated using maximum likelihood (ML) methods. The specification of the multilevel mediation analyses at the student level and the school level is as follows:

Level 1- student level:

$$INM_{ij} = \alpha_{0j} + \alpha_{1j}\,(GENDER) + \alpha_{2j}\,(SES) + \alpha_{3j}(EFF) + \alpha_{4j}(GM) + \varepsilon_{1ij}$$

$$\begin{aligned} MATH_{ij} =& \beta_{0j} + \beta_{1j}\,(GENDER) + \beta_{2j}\,(SES) + \beta_{3j}\,(EFF) + \beta_{4j}\,(GM) \\ &+ \beta_{5j}\,(INM) + \beta_{6j}\,(INM * AUTO) + \beta_{7j}\,(INM * AUTO) + \varepsilon_{2ij} \end{aligned}$$

Level 2- school level:

$$\alpha_{0j} = \gamma_{10} + \gamma_{11}\,(S\_SES) + \gamma_{12}\,(AUTO) + \mu_{2j}$$
$$\beta_{0j} = \gamma_{10} + \gamma_{11}\,(S\_SES) + \gamma_{12}\,(AUTO) + \mu_{2j}$$

Results

Descriptive statistics

The correlations among variables, along with means and standard deviations for each economy, are presented in Online Appendix C. Across all economies, SES showed the strongest positive correlations with mathematics performance, followed by moderate associations with intrinsic motivation and learning effort. Intrinsic motivation was positively correlated with learning effort and growth mindset in all economies. School autonomy showed relatively weak correlations with students' motivational and performance variables. The correlation patterns were generally consistent across the five top-performing Asian (Singapore, Macao, Hong Kong, Taipei, Korea) and Western (Switzerland, Ireland, Denmark, United Kingdom, Poland) economies.

Multilevel mediation analysis

According to the research questions, we examined how students' growth mindset and intrinsic motivation were associated with mathematics performance across the five top-performing Western and Asian economies (Tables 1 and 2).

Growth mindset on mathematics performance

With respect to RQ1, students with a growth mindset were more likely to perform well in mathematics across six economies. In the Western group, this pattern emerged in Switzerland ($\beta = 0.044$, $SE = 0.016$, $p < .01$), Denmark ($\beta = 0.125$, $SE = 0.018$, $p < .001$), the UK ($\beta = 0.149$, $SE = 0.017$, $p < .001$), and Ireland ($\beta = 0.203$, $SE = 0.013$, $p < .001$). In Asia, significant effects were found in Singapore ($\beta = 0.129$, $SE = 0.015$, $p < .001$) and Taipei ($\beta = 0.076$, $SE = 0.026$, $p < .01$). No significant associations were observed in Macao, Hong Kong, Korea, or Poland.

It is also worth noting that learning effort was significantly positively associated with mathematics performance across all ten high-performing Asian and Western economies. Additionally, SES was also positively associated with achievement in nine systems (excluding Hong Kong), while gender differences were evident in five Western and three Asian economies (excluding Korea and Taipei).

Mediation of intrinsic motivation and cultural differences

Five top-performing Western economies (Switzerland, Ireland, Denmark, the United Kingdom, and Poland). Regarding RQ2, students with a growth mindset was more likely to possess intrinsic motivation in Denmark ($\beta = 0.044$, $SE = 0.020$, $p < .05$), UK ($\beta = 0.107$, $SE = 0.017$, $p < .001$), and Ireland ($\beta = 0.148$, $SE = 0.015$, $p < .001$), whereas this relationship was negative in Poland ($\beta = -0.051$, $SE = 0.019$, $p < .01$). Meanwhile, students with higher intrinsic motivation was more inclined to excel in mathematics in Denmark ($\beta = 0.087$, $SE = 0.018$, $p < .001$), Poland ($\beta = 0.056$, $SE = 0.020$, $p < .01$), UK ($\beta = 0.083$, $SE = 0.020$, $p < .001$), and Ireland ($\beta = 0.113$, $SE = 0.016$, $p < .001$), after controlling gender, SES and learning effort. However, in Switzerland, growth mindsets contributed to mathematics achievement independently of intrinsic motivation.

Five top-performing Asian economies (Singapore, Macao, Hong Kong, Taipei, and Korea). Students with growth mindset were more likely to enjoy an engage in mathematics in Singapore ($\beta = 0.093$, $SE = 0.014$, $p < .001$), Macao ($\beta = 0.130$, $SE = 0.018$, $p < .001$), Hong Kong ($\beta = 0.085$, $SE = 0.019$, $p < .001$), Taipei ($\beta = 0.095$, $SE = 0.025$, $p < .001$), and Korea ($\beta = 0.106$, $SE = 0.024$, $p < .001$). Meanwhile, students' enjoyment in mathematics was positively associated with their mathematics performance in Singapore ($\beta = 0.038$, $SE = 0.015$, $p < .01$), Macao ($\beta = 0.133$, $SE = 0.015$, $p < .001$), Hong Kong ($\beta = 0.082$, $SE = 0.019$, $p < .001$), Taipei ($\beta = 0.056$, $SE = 0.021$, $p < .01$), and Korea ($\beta = 0.092$, $SE = 0.031$, $p < .01$), after controlling for gender, SES, and learning effort. In Macao, Korea, and Hong Kong, the effect of mindset on performance operated only through intrinsic motivation.

Cross-level interactions of school autonomy

Five top-performing Western economies (Switzerland, Ireland, Denmark, the United Kingdom, and Poland). Regarding RQ3, students in low-autonomy schools in Poland were more likely to perform better in mathematics than their peers in high-autonomy schools ($\beta = -0.120$, $SE = 0.057$, $p < .05$). However, school autonomy did not significantly

moderate the relationship between growth mindset, intrinsic motivation, and mathematics performance across the five top-performing Western economies.

Five top-performing Asian economies (Singapore, Macao, Hong Kong, Taipei, and Korea). Students in low-autonomy schools in Singapore ($\beta = -0.258$, $SE = 0.093$, $p < .01$) and Taipei ($\beta = -0.187$, $SE = 0.079$, $p < .05$) tended to perform better in mathematics. Comparatively, students in high-autonomy schools in Macao ($\beta = 0.246$, $SE = 0.121$, $p < .05$) and Korea ($\beta = 0.150$, $SE = 0.060$, $p < .05$) excelled in mathematics.

Notably, Korean students in high-autonomy schools were more likely to benefit from a growth mindset to enhance mathematics performance, whereas those in low-autonomy schools tended to perform worse even if they possessed a growth mindset ($\beta = 0.037$, $SE = 0.015$, $p < .05$; Fig. 2). In addition, in Korea, the relationship between intrinsic motivation and mathematics performance was stronger among students in low-autonomy schools ($\beta = -0.086$, $SE = 0.028$, $p < .01$; Fig. 3), and overall mathematics performance was higher in high-autonomy schools. In Singapore, intrinsically motivated students in high-autonomy schools showed greater academic performance gains, despite overall higher average performance in low-autonomy schools ($\beta = 0.031$, $SE = 0.015$, $p < .05$; Fig. 4).

Discussion

With a growing scholarly interest in the psychological and institutional factors underlying student academic achievement, the study aims to understand how motivational beliefs and school contexts jointly shape adolescents' mathematics achievement across cultures. By employing multilevel mediation analyses and PISA 2022 data, the findings indicate that the relationship between growth mindset and mathematics performance varies across different cultural backgrounds, with a positive direct influence in most Western economies, whereas an indirect influence through intrinsic motivation in many Asian economies. Furthermore, the moderating role of school autonomy appears to be complex and context-dependent: it strengthens the impact of growth mindset and intrinsic motivation on mathematics outcomes in some Asian systems, such as Singapore and Korea, but shows no significant moderating influence in the Western countries examined.

Growth mindset on mathematics performance

There were notable differences in the direct influence of growth mindset on mathematics performance between Asian and Western economies. In four out of five Western economies (excluding Poland), students who endorsed a growth mindset tend to outperform their peers in mathematics. This finding aligns with previous research suggesting that a growth mindset is often accompanied by higher levels of autonomy support, mastery-oriented feedback, and self-determined motivation, contributing to better academic outcomes in Western educational systems (Dong & Kang, 2022). In contrast, the similar association between growth mindset on mathematics performance was observed in only two out of five economies: Singapore and Taipei.

Consistent with prior literature, even if Asian students possess a growth mindset, they do not necessarily exhibit significantly better mathematics performance (Boncquet et al., 2023). These students tend to invest greater effort in learning regardless of mindsets, because Asian culture values effort more than intelligence, and this effort is directly associated with better mathematics achievement (Boncquet et al., 2023). From the

Table 1 Multilevel mediation analysis- 5 top-performing Western economies

	Switzerland		Denmark		Poland		United Kingdom		Ireland	
	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)
Student-level										
Primary Variables										
GM	−0.022 (0.017)	0.044 (0.016)**	0.044 (0.020)*	0.125 (0.018)***	−0.051 (0.019)**	−0.021 (0.018)	0.107 (0.017)***	0.149 (0.017)***	0.148 (0.015)***	0.203 (0.013)***
INM		0.033 (0.018)		0.087 (0.018)***		0.056 (0.020)**		0.083 (0.020)***		0.113 (0.016)***
Control Variables										
Gender	0.055 (0.015)***	0.104 (0.015)***	0.104 (0.018)	0.067 (0.016)***	0.044 (0.019)*	0.126 (0.018) ***	0.063 (0.018)***	0.073 (0.015)***	0.029 (0.014)*	0.036 (0.011)***
SES	0.087 (0.016)***	0.349 (0.016) ***	0.091 (0.020)***	0.261 (0.016) ***	0.060 (0.018)**	0.105 (0.024) ***	0.125 (0.015)***	0.184 (0.019)***	0.095 (0.013)***	0.252 (0.014)***
EFF	0.282 (0.017)***	0.093 (0.017)***	0.327 (0.019)***	0.183 (0.021)***	0.244 (0.021)***	0.073 (0.018) ***	0.296 (0.019)***	0.112 (0.019)***	0.287 (0.016)***	0.091 (0.017)***
Interactions										
GM*AUTO		−0.006 (0.015)		−0.007 (0.017)		−0.032 (0.024)		0.004 (0.014)		−0.006 (0.011)
INM*AUTO		0.013 (0.014)		−0.009 (0.020)		−0.004 (0.022)		−0.008 (0.017)		0.009 (0.016)
Residual Var	0.907 (0.010)***	0.849 (0.012) ***	0.873 (0.013)***	0.853 (0.012)***	0.928 (0.011)***	0.957 (0.008) ***	0.870 (0.012)***	0.898 (0.009)***	0.880 (0.010)***	0.844 (0.009)***
R^2	9.2%	13.7%	12.7%	14.7%	7.2%	4.3%	13.0%	10.2%	11.9%	15.6%
School-level										
Primary Variables										
AUTO		−0.071 (0.071)		0.042 (0.089)		−0.120 (0.057)*		0.062 (0.074)		0.079 (0.099)
Control Variables										
S_SES		0.694 (0.057)***		0.620 (0.081)***		0.847 (0.036)***		0.597 (0.073)***		0.719 (0.078)***

Table 1 (continued)

	Switzerland		Denmark		Poland		United Kingdom		Ireland	
	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)
Residual Var		0.532 (0.077)***		0.603 (0.097)***		0.286 (0.057)***		0.622 (0.088)***		0.452 (0.102)***
R^2		46.8%		39.7%		71.4%		37.8%		54.8%

GM growth mindset, *EFF* effort belief, *AUTO* school autonomy, *INM* Intrinsic Motivation, *S_SES* school mean socioeconomic status

*$p < .05$, ** $p < .01$, *** $p < .001$

Table 2 Multilevel mediation analysis—5 top-performing Asian economies

	Singapore		Macao		Hong Kong		Taipei		Korea	
	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)
Student-level										
Primary Variables										
GM	0.093 (0.014)***	0.129 (0.015)***	0.130 (0.018)***	0.013 (0.018)	0.085 (0.019)***	−0.010 (0.017)	0.095 (0.025)***	0.076 (0.026)**	0.106 (0.024)***	−0.006 (0.028)
INM		0.038 (0.015)**		0.133 (0.015)***		0.082 (0.019)***		0.056 (0.021)**		0.092 (0.031)**
Control Variables										
Gender	0.120 (0.014)***	0.093 (0.014)***	0.113 (0.019)***	0.136 (0.016)***	0.080 (0.015)***	0.079 (0.018)***	0.115 (0.016)***	−0.021 (0.024)	0.182 (0.028)***	0.055 (0.040)
SES	0.068 (0.012)***	0.283 (0.014)***	0.058 (0.019)**	0.093 (0.019)***	0.075 (0.015)***	0.033 (0.019)	0.056 (0.020)**	0.193 (0.030)***	0.161 (0.034)***	0.182 (0.033)***
EFF	0.297 (0.017)***	0.046 (0.012)***	0.319 (0.016)***	0.103 (0.019)***	0.301 (0.015)***	0.103 (0.017)***	0.304 (0.021)***	0.171 (0.026)***	0.292 (0.032)***	0.238 (0.029)***
Interactions										
GM*AUTO		−0.020 (0.016)		−0.011 (0.012)		−0.023 (0.021)		0.026 (0.020)		0.037 (0.015)*
INM*AUTO		0.031 (0.015)*		0.000 (0.010)		0.016 (0.019)		0.018 (0.017)		−0.086 (0.028)**
Student-level Residual Variances	0.883 (0.010)***	0.884 (0.010)***	0.863 (0.014)***	0.929 (0.007)***	0.884 (0.010)***	0.967 (0.006)***	0.876 (0.013)***	0.902 (0.013)***	0.826 (0.026)***	0.851 (0.021)***
R^2	11.7%	11.6%	13.7%	7.1%	11.6%	3.3%	13.0%	10.2%	17.4%	14.9%
School-level										
Primary Variables										
AUTO		−0.258 (0.093)**		0.246 (0.121)*		−0.023(0.105)		−0.187 (0.079)*		0.150 (0.060)*
Control Variables										

Table 2 (continued)

	Singapore		Macao		Hong Kong		Taipei		Korea	
	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)	Intrinsic motivation β (SE)	Math performance β (SE)
S_SES		0.757 (0.059)***		0.439 (0.103)***		0.616 (0.067)***		0.801 (0.074)***		0.711 (0.089)***
Residual Var		0.565 (0.068)***		0.727 (0.104)***		0.621 (0.078)***		0.384 (0.110)***		0.477 (0.127)***
R^2		43.5%		27.3%		37.9%		61.6%		52.3%

GM growth mindset, *EFF* effort belief, *AUTO* school autonomy, *INM* Intrinsic Motivation, *S_SES* school mean socioeconomic status

*$p < .05$, ** $p < .01$, *** $p < .001$

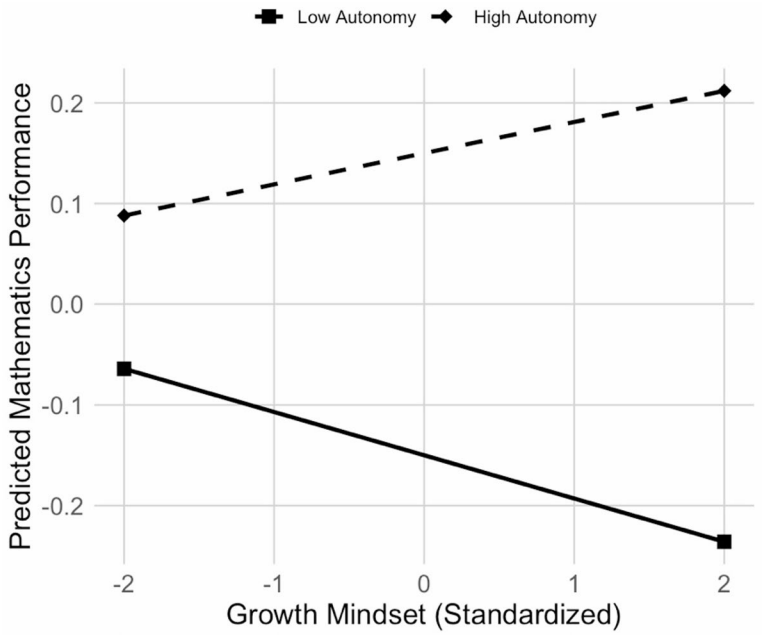

Fig. 2 Impact of school autonomy on the relationship between growth mindset and mathematics performance in Korea

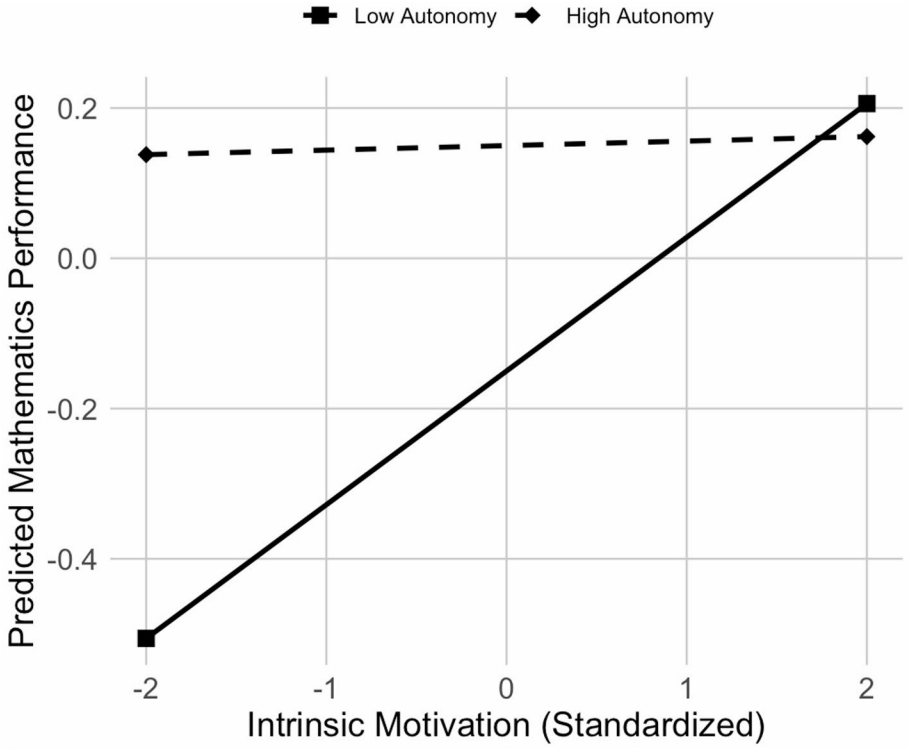

Fig. 3 Impact of school autonomy on the relationship between intrinsic motivation and mathematics performance in Korea

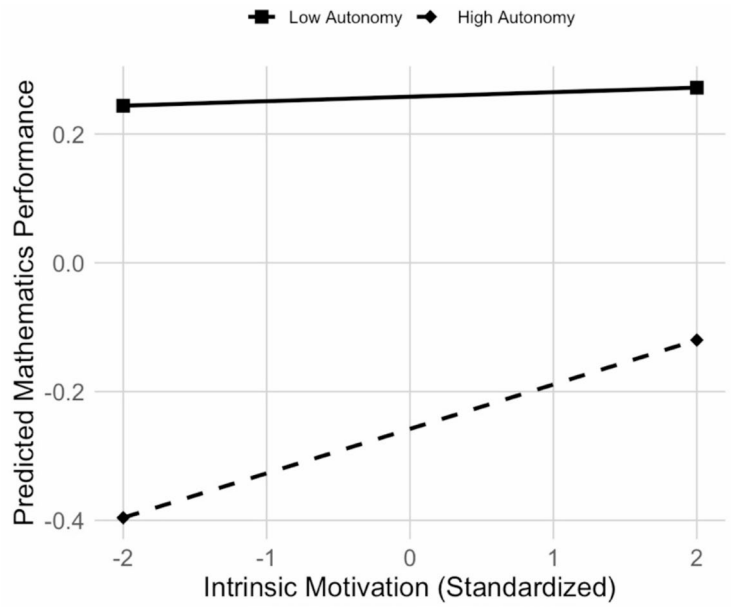

Fig. 4 Impact of school autonomy on the relationship between intrinsic motivation and mathematics performance in Singapore

perspective of SDT, in Macao, Hong Kong, and Korea, students' beliefs in the malleability of intelligence appear to remain largely externally motivated. Although they endorse a growth mindset, their motivation to study is often driven by external demands, social expectations, or the avoidance of guilt and failure, thereby sustaining contingent self-esteem rather than intrinsic interest.

However, in Singapore and Taipei, stronger societal endorsement of a growth mindset contributes to a learning environment where students' basic psychological needs are readily satisfied, facilitating the internalisation of motivation and the direct translation of growth mindset and competence into academic performance (Liman et al., 2023). Thus, these students have more fully internalized and integrated the growth mindset into their sense of competence and identity. Their learning is guided by intrinsic motives such as curiosity, enjoyment, and a genuine desire to master challenges, reflecting identified or integrated self-regulation.

The mediating role of intrinsic motivation

This study found that students' intrinsic motivation mediated the relationship between growth mindset and mathematics performance in many Asian economies. Although there was no significant direct influence of growth mindset on mathematics performance in Macao, Hong Kong, and Korea, the relationship was fully mediated by students' intrinsic motivation. Asian students with a growth mindset tend to be more intrinsically motivated, which in turn supports their learning and leads to progress in mathematics. In contrast, in Singapore and Taipei, students with a growth mindset not only achieve better mathematics performance but also report greater enjoyment and engagement in learning, which further contributes to higher academic achievement.

In Western economies, the mediation effect was observed in Denmark, the United Kingdom, and Ireland, where intrinsic motivation amplified the benefits of a growth mindset. However, in Switzerland, intrinsic motivation did not mediate the relationship

between a growth mindset and students' mathematics performance. In other words, students who believe that their intellect and ability can be promoted are more likely to have higher academic achievement regardless of their enjoyment of mathematics. Similarly, a recent review study found that German and Swiss students' self-regulated learning strategies had smaller associations with growth mindset than their peers in East Asian contexts (e.g., Hong Kong; Xu et al., 2025). This pattern suggests that the motivational pathways through which growth mindset operates may be more context-dependent in Western systems.

Surprisingly, in Poland, students with a fixed mindset were more likely to have better mathematics performance. Those students exhibited higher intrinsic motivation, which in turn supports their mathematics achievement through greater interest, engagement, and persistence. One possible explanation for this mediation pattern is that in Poland, where performance and natural talent are valued (a fixed-mindset norm), it is more difficult for students to translate their growth beliefs into learning behaviors and academic success (Liman et al., 2023). Thus, when students' personal growth mindsets are misaligned with prevailing societal mindsets, it may hinder their progress in mathematics.

Additionally, from 2009 to 2018, learning outcomes in Poland improved significantly for high achievers but showed no clear change for low achievers, which may have reinforced the fixed-mindset norm (Jakubowski, 2020). Students identified as gifted in mathematics who consistently perform well may grow up in environments where their abilities are frequently praised and reinforced, which can unintentionally promote a fixed mindset, heighten fear of failure, and reduce intrinsic motivation (Danielian et al., 2021). Therefore, it is essential for future research to consider students' prior learning experiences in mathematics in relation to their mindset and to promote the development of intrinsic motivation as a pathway to sustained academic progress.

The moderator of school autonomy

School autonomy showed complex and context-dependent associations with mathematics achievement, with notable contrasts between Asian and Western economies. The findings do not align with previous research that school autonomy is generally beneficial in high-income countries (Hanushek et al., 2013). Among the five examined Western educational systems, only Poland showed a direct effect, where higher school autonomy was associated with lower mathematics performance. This suggests that greater decentralization of school management may not absolutely translate into better academic outcomes, especially in contexts where accountability and institutional support remain uneven (Nuță et al., 2022).

In the Asian economies, the patterns were more diverse. In Singapore and Taipei, where top-down educational systems are characterized by centralized control and constrained autonomy, higher levels of school autonomy can be associated with lower student mathematics performance (Coudenys et al., 2022; Dimmock & Tan, 2016). Taiwan policy further illustrates these challenges: despite their emphasis on school-level decision-making, reforms have often conflicted with centralized accountability systems, resulting in uneven implementation and bureaucratization rather than genuine empowerment (Coudenys et al., 2022; Lo, 2010). In contrast, students in high-autonomy schools in Macao and Korea tended to achieve better academic performance.

Beyond these direct associations, the moderating role of school autonomy in the relationship between students' motivational beliefs and mathematics achievement also varied across contexts. School autonomy did not show a clear moderating effect in the relationship between students' motivational beliefs and mathematics achievement in any of the Western economies. This result implies that structural autonomy alone may be insufficient to enhance motivational pathways without additional contextual supports such as principal leadership, teacher efficacy, and family involvement (Jackson, 2023).

In contrast, moderating effects of school autonomy were more evident in the Asian economies, though the mechanisms varied. In Singapore, educational reforms have promoted autonomy in curriculum development and teacher support, insufficient local capacity and weak accountability can turn autonomy into a bureaucratic burden, constraining its effectiveness (King & Guerra, 2005; Torres, 2021). But, Singapore's model of school autonomy is embedded within a robust framework of high-stakes accountability and institutional support, which has contributed to consistently strong student outcomes (OECD, 2011). Consequently, school autonomy positively moderated the relationship between intrinsic motivation and students' mathematics performance in Singapore. When students attend schools with higher levels of autonomy, their intrinsic motivation is likely to benefit their mathematics learning more. Therefore, under proper institutional conditions, school autonomy can enhance the influence of intrinsic motivation on student performance.

Interestingly, in Korea, school autonomy strengthened the influence of growth mindset on mathematics achievement in high-autonomy schools, while it enhanced the influence of intrinsic motivation in low-autonomy schools. On the one hand, a growth mindset only benefits students' mathematics performance in contexts where school autonomy is high. This moderating effect may be explained by the implementation of the Innovative Schools policy, a bottom-up, locally driven reform that promotes democratic governance, student participation, and curricular flexibility. This policy cultivates an autonomy-supportive environment that amplifies the impact of the growth mindset by enabling students to exercise greater agency and engage in adaptive learning strategies (Miho Taguma, 2024). On the other hand, when school autonomy is low, principals and teachers have limited opportunities for decision-making, placing greater responsibility on students and parents regarding academic outcomes. In such contexts, the positive effect of intrinsic motivation on mathematics performance is more pronounced, as observed in low-autonomy schools in Korea. When institutional structures provide less guidance or support, students appear to rely more heavily on their internal motivation to achieve academic success.

Theoretical and empirical implications

This study yields several important insights into how growth mindset and intrinsic motivation shape mathematics performance across diverse cultural and educational contexts. First, the relationship between growth mindset and mathematics achievement was evident in two Asian economies (Singapore and Taipei) and four Western economies (Switzerland, Denmark, the United Kingdom, and Ireland). A counterintuitive result emerged in Poland, where a growth mindset was associated with lower mathematics performance. This finding challenges the predictions of the implicit theories of intelligence and may reflect the dominance of fixed-mindset societal norms in Poland, particularly in

mathematics. The mismatch between students' beliefs and prevailing cultural expectations may therefore undermine achievement. Future research should further investigate how societal norms shape the operation of motivational constructs (Dweck, 2024).

Second, the mechanisms underlying the relationship between growth mindset and mathematics achievement differ across educational systems. Intrinsic motivation was a robust mediator in all five Asian economies and four Western economies (Denmark, the UK, Ireland, and Poland). Notably, in Poland, Macao, Hong Kong, and Korea, the relationship between growth mindset and mathematics performance was fully mediated by intrinsic motivation. These findings underscore the importance of cultivating students' intrinsic motivation to maximize the benefits of a growth mindset on academic outcomes, particularly in culturally diverse settings.

Third, the influence of school autonomy on mathematics performance varies across economies. The interaction between school autonomy and the growth mindset–performance link suggests that the effectiveness of mindset interventions may depend on the broader institutional context. For example, in Korea, students who hold a fixed mindset can still achieve relatively strong performance in mathematics when attending schools with lower levels of autonomy. This indicates that in highly structured environments in Korea, external regulation may partially compensate for students' lower belief in intellectual malleability. Thus, this study offers a contextual perspective on the influence of growth mindset on mathematics performance by highlighting the role of school autonomy in shaping academic outcomes. This shifts the focus beyond individual personality traits to include structural and environmental influences.

In sum, the effect of growth mindset on mathematics performance is not universal but contingent on cultural, motivational, and institutional factors. The observed cross-cultural contrasts underscore that motivational mechanisms and institutional structures interact differently across educational systems. These findings highlight the need for culturally responsive interventions that align students' motivational orientations with the structural characteristics of schools. Practically, in the top-performing Asian economies and Western economies (Denmark, United Kingdom and Ireland), students can benefit from cultivating intrinsic motivation to translate growth mindset beliefs into improved achievement. Teachers can foster classroom environments that support engagement and interest in mathematics. School administrators should consider how levels of school autonomy shape motivational processes. Policymakers may need to adapt motivational interventions to specific educational contexts..

Limitations

Although this study offered valuable empirical insights, several limitations should be acknowledged. First, the analyses relied on cross-sectional data from PISA 2022, which constrained the interpretation of findings to correlational relationships rather than causal inference. Longitudinal research would be beneficial to explore the developmental trajectories of intrinsic motivation and growth mindset and their evolving impact on mathematics achievement over time. Second, as fixed and growth mindsets might co-exist within individuals, the use of single-item measures potentially introduced acquiescence bias and lower reliability (Barroso et al., 2023; Scherer & Campos, 2022). In some Asian educational systems, for example, students can display a paradoxical mindset pattern: they endorse a growth mindset toward academic performance

but simultaneously hold a fixed mindset about innate intelligence (Liman et al., 2023; Regional Educational Laboratory Northwest, 2017). Third, due to limitations in data availability, this study focused exclusively on examining the moderating role of school autonomy. Future research should incorporate additional school-level variables, such as school accountability, teacher efficacy, and teacher–student relationships, to yield a more comprehensive understanding of how school management practices influence students' mathematics achievement (Fu et al., 2023). Finally, mathematics achievement in PISA is estimated using plausible values rather than directly observed scores, which may introduce additional sampling variability and affect the precision of individual-level estimates (Jewsbury et al., 2024; Rutkowski et al., 2010). Future research can use complementary assessment data, such as standardized test scores or administrative academic records, which could help validate the robustness of the observed relationships.

Conclusions

This study contributes to the literature by integrating psychological factors (growth mindset, intrinsic motivation) and institutional factors (school autonomy) to explain cross-national differences in mathematics performance. Specifically, it showed that a growth mindset influenced mathematics achievement both directly and indirectly through intrinsic motivation across high-performing Asian and Western economies. The mediating role of intrinsic motivation proved particularly robust in Macao, Hong Kong, Korea, and Poland, where it fully accounted for the relationship between growth mindset and mathematics performance. Moreover, school autonomy exhibited limited yet context-dependent moderating effects. In Korea, although students in high-autonomy schools performed better in mathematics on average, greater intrinsic motivation was related to better achievement in low-autonomy schools. In contrast, in Singapore, where average mathematics scores were better in low-autonomy schools, greater school autonomy amplified the positive influence of intrinsic motivation on students' mathematics performance.

Overall, these findings highlight that the links between motivational beliefs and mathematics achievement are shaped by broader cultural and institutional contexts. Comparative analyses of similarities and differences among high-performing systems can inform the design of contextually responsive practices and policies to enhance mathematics learning and guide efforts to adapt these strategies in underperforming systems to improve global mathematics proficiency.

Supplementary Information

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Supplementary Material 1

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Author contributions
Yuanyi Zhu contributed to the conceptualization, literature review, data analysis, and drafting of the manuscript. Luyang Guo contributed to the study design, theoretical supervision, and overall revision of the manuscript. Both authors read and approved the final version of the manuscript.

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Data availability
The data used in this study are publicly available from the OECD Programme for International Student Assessment (PISA 2022) database: https://www.oecd.org/pisa/data/2022database/

Declarations

Competing interests
The authors declare no competing interests.

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References

Altikulaç, S., Janssen, T. W. P., Yu, J., Nieuwenhuis, S., & Van Atteveldt, N. M. (2024). Mindset profiles of secondary school students: Associations with academic achievement, motivation and school burnout symptoms. *British Journal of Educational Psychology, 94*(3), 738–758. https://doi.org/10.1111/bjep.12676

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teaching behaviors. *British Journal of Educational Psychology, 72*(2), 261–278.

Barroso, C., Ganley, C. M., Schoen, R. C., & Schatschneider, C. (2023). Between a growth and a fixed mindset: Examining nuances in 3rd-grade students' mathematics intelligence mindsets. *Contemporary Educational Psychology, 73*, Article 102179. https://doi.org/10.1016/j.cedpsych.2023.102179

Boncquet, M., Flamant, N., Lavrijsen, J., Vansteenkiste, M., Verschueren, K., & Soenens, B. (2023). The unique importance of motivation and mindsets for students' learning behavior and achievement: An examination at the level of between-student differences and within-student fluctuations. *Journal of Educational Psychology, 116*(3), 448–465. https://doi.org/10.1037/edu0000827

Buerger, C., Lincove, J. A., & Mata, C. (2023). How context shapes the relationship between school autonomy and test scores. An explanatory analysis using PISA 2015. *International Journal of Educational Development, 99*, Article 102777. https://doi.org/10.1016/j.ijedudev.2023.102777

Carmichael, C., Muir, T., & Callingham, R. (2017). The impact of within-school autonomy on students' goal orientations and engagement with mathematics. *Mathematics Education Research Journal, 29*(2), 219–236. https://doi.org/10.1007/s13394-017-0200-z

Cook, D. A., & Artino, A. R. (2016). Motivation to learn: An overview of contemporary theories. *Medical Education, 50*(10), 997–1014. https://doi.org/10.1111/medu.13074

Coudenys, B., Strohbach, G., Tang, T., & Udabe, R. (2022). On the path toward lifelong learning: An early analysis of Taiwan's 12-year basic education reform. In F. M. Reimers, U. Amaechi, A. Banerji, & M. Wang (Eds.), *Education to build back better: What can we learn from education reform for a post-pandemic world* (pp. 75–98). Springer International Publishing. https://doi.org/10.1007/978-3-030-93951-9_4

Danielian, J., Fugate, C. M., & Fogarty, E. (2021). *Teaching gifted children: Success strategies for teaching high-ability learners*. Routledge.

von Davier, M., Kennedy, A., Reynolds, K., Fishbein, B., Khorramdel, L., Aldrich, C., Bookbinder, A., Bezirhan, U., & Yin, L. (2024). *TIMSS 2023 international results in mathematics and science*. https://doi.org/10.6017/lse.tpisc.timss.rs6460.

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268. https://doi.org/10.1207/s15327965pli1104_01

Dimmock, C., & Tan, C. Y. (2016). Explaining the success of the world's leading education systems: The case of Singapore. *British Journal of Educational Studies, 64*(2), 161–184. https://doi.org/10.1080/00071005.2015.1116682

Dong, L., Jia, X., & Fei, Y. (2023). How growth mindset influences mathematics achievements: A study of Chinese middle school students. *Frontiers in Psychology, 14*, 1148754. https://doi.org/10.3389/fpsyg.2023.1148754

Dong, L., & Kang, Y. (2022). Cultural differences in mindset beliefs regarding mathematics learning. *Current Opinion in Behavioral Sciences, 46*, Article 101159. https://doi.org/10.1016/j.cobeha.2022.101159

Dutt, D. D. C. S., Razavi, H., & Carr, S. E. (2023). Self-determination theory in ophthalmology education: Factors influencing autonomy, competence and relatedness in medical students. *Medical Education Online*. https://doi.org/10.1080/10872981.2023.2258633

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development* (1st ed.). Psychology Press. https://doi.org/10.4324/9781315783048

Dweck, C. S. (2008). Mindsets: How praise is harming youth and what can be done about it. *School Library Media Activities Monthly, 24*(5), 55–58.

Dweck, C. S. (2024). Personal perspectives on mindsets, motivation, and psychology. *Motivation Science, 10*(1), 1–8. https://doi.org/10.1037/mot0000304

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256–273. https://doi.org/10.1037/0033-295x.95.2.256

Ersan, O., & Rodriguez, M. C. (2020). Socioeconomic status and beyond: A multilevel analysis of TIMSS mathematics achievement given student and school context in Turkey. *Large-Scale Assessments in Education, 8*(1), 1–32. https://doi.org/10.1186/s40536-020-00093-y

Farzan, I. A. (2018). *The interplay of culture, motivation, and self: An investigation of math achievement gap between middle school students in the us and those in the top-performing countries in east Asia* (Doctoral dissertation, University of Memphis). ProQuest Dissertations Publishing.

Fu, D., Liu, Y., & Zhang, D. (2023). The relationship between teacher autonomy support and student mathematics achievement: A 3-year longitudinal study. *Educational Psychology, 43*(2–3), 187–206. https://doi.org/10.1080/01443410.2023.2190064

Hanushek, E. A., Link, S., & Woessmann, L. (2013). Does school autonomy make sense everywhere? Panel estimates from PISA. *Journal of Development Economics, 104*, 212–232. https://doi.org/10.1016/j.jdeveco.2012.08.002
Hanushek, E. A., & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature, 46*(3), 607–668. https://doi.org/10.1257/jel.46.3.607
Hu, X., Leung, F. K. S., & Teng, Y. (2018). The influence of culture on students' mathematics achievement across 51 countries. *International Journal of Science and Mathematics Education, 16*, 7–24. https://doi.org/10.1007/s10763-018-9899-6
Huang, M. (2025). How growth mindset reduces math anxiety across cultures: Mediating roles of autonomy, competence, and relatedness in PISA 2022. *Acta Psychologica, 261*, Article 105902. https://doi.org/10.1016/j.actpsy.2025.105902
Irvine, J. (2018). A framework for comparing theories related to motivation in education. *Research in Higher Education Journal, 35*, 30.
Jackson, C. K. (2023). When does school autonomy improve student outcomes? EdWorkingPaper No. 23–808. *Annenberg Institute for School Reform at Brown University*. https://doi.org/10.26300/cdj7-rg41.
Jakubowski, M. (2020). Poland: Polish education reforms and evidence from international assessments. *Improving a Country's Education: PISA 2018 Results in 10 Countries*, 137–158. https://doi.org/10.1007/978-3-030-59031-4_7.
Jewsbury, P. A., Jia, Y., & Gonzalez, E. J. (2024). Considerations for the use of plausible values in large-scale assessments. *Large-Scale Assessments in Education, 12*(1), Article 24. https://doi.org/10.1186/s40536-024-00213-y
Johnston-Wilder, S., Lee, C., & Mackrell, K. (2021). Addressing mathematics anxiety through developing resilience: Building on self-determination theory. *Creative Education, 12*(9), 2098–2115. https://doi.org/10.4236/ce.2021.129161
Jumangit, E. A., & Miranda, A. T. (2025). The mediating effect of mathematics motivation on the relationship between mathematical mindset and performance. *Asian Journal of Education and Social Studies, 51*(5), 686–697. https://doi.org/10.9734/ajess/2025/v51i51951
Kane, T. J., Doty, E., Patterson, T., & Staiger, D. O. (2022). *What Do Changes in State Test Scores Imply for Later Life Outcomes?* (NBER Working Paper No. 30701). National Bureau of Economic Research. https://doi.org/10.3386/w30701.
Karlen, Y., Suter, F., Hirt, C., & Maag Merki, K. (2019). The role of implicit theories in students' grit, achievement goals, intrinsic and extrinsic motivation, and achievement in the context of a long-term challenging task. *Learning and Individual Differences, 74*, Article 101757. https://doi.org/10.1016/j.lindif.2019.101757
Khanal, S., & Guha, P. (2023). Exploring the relationship between school-based management and school climate using PISA data. *Asia Pacific Education Review, 24*, 1–15. https://doi.org/10.1007/s12564-023-09846-0
King, E. M., & Guerra, S. C. (2005). Education reforms in East Asia: Policy, process, and impact. *East Asia Decentralizes: Making Local Government Work*, 179–208.
Koedel, C., & Tyhurst, E. (2012). Math skills and labor-market outcomes: Evidence from a resume-based field experiment. *Economics of Education Review, 31*(1), 131–140. https://doi.org/10.1016/j.econedurev.2011.09.006
Landoll, R. R., Bennion, L. D., & Maggio, L. A. (2021). Understanding excellence: A qualitative analysis of high-performing learner study strategies. *Medical Science Educator, 31*(3), 1101–1108. https://doi.org/10.1007/s40670-021-01279-x
Lastra-Anadón, C. X., & Mukherjee, S. (2019). *Cross-country evidence on the impact of decentralisation and school autonomy on educational performance*. (OECD Working Papers on Fiscal Federalism No. 29). OECD Publishing. https://doi.org/10.1787/dafb72ae-en.
Lay, Y. F., & Chandrasegaran, A. L. (2016). The predictive effects of motivation toward learning science on TIMSS grade 8 students' science achievement: A comparative study between Malaysia and Singapore. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(12), 2949–2959. https://doi.org/10.12973/eurasia.2016.02315a
Lee, J. (2014). Universal factors of student achievement in high-performing eastern and western countries. *Journal of Educational Psychology, 106*(2), 364–374. https://doi.org/10.1037/a0035609
Liman, C., Li, M. W., Lou, N. M., & Liman, I. (2023). The mindsets × societal norm effect across 78 cultures: Growth mindsets are linked to performance weakly and well-being negatively in societies with fixed-mindset norms. *British Journal of Educational Psychology, 93*(1), 134–152. https://doi.org/10.1111/bjep.12544
Liu, W. C. (2021). Implicit theories of intelligence and achievement goals: A look at students' intrinsic motivation and achievement in mathematics. *Frontiers in Psychology, 12*, Article 593715. https://doi.org/10.3389/fpsyg.2021.593715
Lo, W. Y. W. (2010). Decentralization of higher education and its implications for educational autonomy in Taiwan. *Asia Pacific Journal of Education, 30*(2), 127–139. https://doi.org/10.1080/02188791003721572
Montgomery, D. P., Montgomery, M., & Montgomery, M. (2023). Theories of motivation to support the needs of all learners. *Learning Landscapes, 16*(1), 213–227. https://doi.org/10.36510/learnland.v16i1.1098
Muthén, L. K., & Muthén, B. O. (2017). Mplus user's guide (8th ed.). Muthén & Muthén. https://www.statmodel.com.
Naveed, A., Zhuparova, A., Ashfaq, M., & Rauf, A. (2023). The effect of average scores in reading, mathematics and science on innovation and income: A quantitative analysis for a group of countries. *Heliyon, 9*(9), Article e19213. https://doi.org/10.1016/j.heliyon.2023.e19213
Niu, J., Xu, H., & Yu, J. (2025). Identifying multilevel factors on student mathematics performance for Singapore, Korea, Finland, and Denmark in PISA 2022: Considering individualistic versus collectivistic cultures. *Humanities and Social Sciences Communications, 12*(1), 1–12. https://doi.org/10.1057/s41599-025-04466-y
Regional Educational Laboratory Northwest. (2017). *Improving Students' Attitudes and Beliefs About Mathematics: A literature summary of research-based practices and strategies.* (RELNW 5.2.W02.2). U.S. Department of Education, Institute of Education Sciences. https://nces.ed.gov/sites/default/files/migrated/rel/regions/northwest/pdf/math-attitudes-training/building-positive-math-attitudes-literature-summary.pdf.
Nuță, A. C. C., Lupu, D., & Nuță, F. M. (2022). The impact of public education spending on economic growth in Central and Eastern Europe. An ARDL approach with structural break. *Economic Research-Ekonomska Istraživanja, 36*(1), 1261–1278. https://doi.org/10.1080/1331677x.2022.2086147
O'Keefe, P. A., Horberg, E. J., Dweck, C. S., & Walton, G. M. (2023). A Growth-Theory-of-Interest intervention increases interest in Math and science coursework among Liberal Arts undergraduates. *Journal of Educational Psychology, 115*(6), 859–876. https://doi.org/10.1037/edu0000798
OECD. (2011). *School Autonomy and Accountability: Are They Related to Student Performance?* (PISA in Focus, Vol. 9). https://doi.org/10.1787/5k9h362kcx9w-en
OECD. (2023a). *PISA 2022 Results (Volume I)*. OECD. https://doi.org/10.1787/53f23881-en.
OECD. (2023b). *PISA 2022 Results (Volume II)*. OECD. https://doi.org/10.1787/a97db61c-en.

OECD. (2024a). An evolution of mathematics curriculum: Where it was, where it stands and where it is going. OECD Publishing. https://doi.org/10.1787/0ffd89d0-en.
OECD. (2024b). *PISA 2022 Technical Report*. https://doi.org/10.1787/01820d6d-en.
Pang, J. S., & Seah, W. T. (2021). Excellent mathematical performance despite "negative" affect of students in Korea: The values perspective. *ECNU Review of Education, 4*(2), 285–306. https://doi.org/10.1177/2096531120930726
Rammstedt, B., Grüning, D. J., & Lechner, C. M. (2024). Measuring Growth Mindset: Validation of a three-item and a single-item scale in adolescents and adults. *European Journal of Psychological Assessment, 40*(1), 84–95. https://doi.org/10.1027/1015-5759/a000735
Renaud-Dubé, A., Guay, F., Talbot, D., Taylor, G., & Koestner, R. (2015). The relations between implicit intelligence beliefs, autonomous academic motivation, and school persistence intentions: A mediation model. *Social Psychology of Education, 18*(2), 255–272. https://doi.org/10.1007/s11218-014-9288-0
Rutkowski, L., Gonzalez, E., Joncas, M., & Von Davier, M. (2010). International large-scale assessment data: Issues in secondary analysis and reporting. *Educational Researcher, 39*(2), 142–151.
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066x.55.1.68
Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.
Ryan, R. M., & Deci, E. L. (2022). Self-determination theory. In F. Maggino (Ed.), *Encyclopedia of quality of life and well-being research* (pp. 1–7). Springer Nature Switzerlan. https://doi.org/10.1007/978-3-319-69909-7_2630-2
Ryu, E., & West, S. G. (2009). Level-specific evaluation of model fit in multilevel structural equation modeling. *Structural Equation Modeling, 16*(4), 583–601. https://doi.org/10.1080/10705510903203466
Scherer, R., & Campos, D. G. (2022). Measuring those who have their minds set: An item-level meta-analysis of the implicit theories of intelligence scale in education. *Educational Research Review, 37*, Article 100479. https://doi.org/10.1016/j.edurev.2022.100479
Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science, 29*(4), 549–571. https://doi.org/10.1177/0956797617739704
Soe, H. Y., Zhang, D., Fu, D., & Cui, Y. (2025). How an autonomy-supportive learning environment influences students' achievements in science and mathematics. *Social Psychology of Education, 28*(1), 1–35. https://doi.org/10.1007/s11218-024-09970-8
Sriutaisuk, S., Huansuriya, T., & Master, A. (2024). Growth mindsets, workmastery, and socioeconomic status interact in predicting achievement of adolescents in Southeast Asia. *Kasetsart Journal of Social Sciences -- Kasetsart Journal (Social Sciences), 45*(3), 1025–1036. https://doi.org/10.34044/j.kjss.2024.45.3.31
Stohlmann, M., & Yang, Y. (2024). Growth mindset in high school mathematics: A review of the literature since 2007. *Journal of Pedagogical Research, 8*(2), 357–370. https://doi.org/10.33902/jpr.202424437
Taguma, M. (2024). *Re thinking future education in Korea: Towards student agency and well-being*. OECD. https://www.oecd.org/content/dam/oecd/en/about/projects/edu/education-2040/6-bilateral-support/Re-thinking_Future_Education_in_Korea.pdf.
Torres, R. (2021). *Does test-based school accountability have an impact on student achievement and equity in education? A panel approach using PISA* (OECD Education Working Papers, No. 250). OECD Publishing. https://doi.org/10.1787/0798600f-en.
van Hoeve, M., Doorman, M., & Veldhuis, M. (2023). Fostering a growth mindset in secondary mathematics classrooms in the Netherlands. *Research in Mathematics Education, 27*(1), 92–113. https://doi.org/10.1080/14794802.2023.2241433
Wang, C., Cho, H. J., Wiles, B., Moss, J. D., Bonem, E. M., Li, Q., Lu, Y., & Levesque-Bristol, C. (2022). Competence and autonomous motivation as motivational predictors of college students' mathematics achievement: From the perspective of self-determination theory. *International Journal of STEM Education, 9*, Article 41. https://doi.org/10.1186/s40594-022-00359-7
Wang, X. S., Perry, L. B., Malpique, A., & Ide, T. (2023). Factors predicting mathematics achievement in PISA: A systematic review. *Large-Scale Assessments in Education, 11*, 1–42. https://doi.org/10.1186/s40536-023-00174-8
Watts, T. W. (2020). Academic achievement and economic attainment: Reexamining associations between test scores and long-run earnings. *AERA Open*. https://doi.org/10.1177/2332858420928985
Xu, J. (2020). Longitudinal effects of homework expectancy, value, effort, and achievement: An empirical investigation. *International Journal of Educational Research, 99*, Article 101507. https://doi.org/10.1016/j.ijer.2019.101507
Xu, K. M., Leferink, J., & Wijnia, L. (2025). A review of the relationship between student growth mindset and self-regulated learning. *Frontiers in Education, 10*, Article 1539639. https://doi.org/10.3389/feduc.2025.1539639
Yeager, D. S., & Dweck, C. S. (2020). What can be learned from growth mindset controversies? *American Psychologist, 75*(9), 1269–1284. https://doi.org/10.1037/amp0000794
Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., Tipton, E., Schneider, B., Hulleman, C. S., Hinojosa, C. P., Paunesku, D., Romero, C., Flint, K., Roberts, A., Trott, J., Iachan, R., Buontempo, J., Yang, S. M., Carvalho, C. M., … Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature, 573*(7774), 364–369. https://doi.org/10.1038/s41586-019-1466-y
Zeeshan, M. (2025). Examining the effects of growth mindset strategies on middle school students' performance in mathematics in Georgia, USA. *European Journal of Education and Pedagogy, 6*(5), 9–12. https://doi.org/10.24018/ejedu.2025.6.5.990

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