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Beyond academic results: motivational and emotional factors as indicators of educational effectiveness in mathematics

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ABSTRACT Evaluating educational effectiveness based solely on academic results obscures essential aspects of student development. This study examines the relevance of motivational and affective indicators as complementary criteria for academic effectiveness in mathematics. Six dimensions were analyzed: interest in mathematics, perceived usefulness, perceived difficulty, expectations of success, self-efficacy, and mathematical anxiety. The methodology is based on two validated instruments, supplemented by teacher evaluations. The results confirm the importance of non-cognitive factors: self-efficacy correlates positively with performance and negatively with anxiety and perceived difficulty. Significant gender differences emerge, with boys showing higher self-efficacy than girls. Mathematics anxiety is a major obstacle to learning, particularly for struggling students. This research calls for a broader conceptualization of educational effectiveness that integrates cognitive, motivational, and emotional dimensions to better support all students.

KEYWORDS: *Educational effectiveness; Self-efficacy; Mathematics anxiety; Non-cognitive factors; Academic motivation*

Introduction

Educational effectiveness is traditionally measured through academic performance, such as standardized test scores. However, this exclusive approach remains restrictive and questionable (Grützmacher et al., 2021), as it obscures the diversity of the school system's objectives, which also include the development of social and emotional skills, essential to the overall development of students (Fend, 2009) . Furthermore, the assessment of skills, particularly in complex subjects such as mathematics, cannot be reduced to purely cognitive measures (Fagnant et al., 2014). Motivational and affective factors play a central role in learning and academic success. Indeed, self-confidence, interest in the subject, perception of self-control, and motivation influence participation, perseverance, and performance in mathematics (Antunes & Fontaine, 2007; Fernández-Villaverde et al., 2015; Ma & Xu, 2004; Marsh & O'Mara, 2010; Schiefele et al., 2012; Xiao & Sun, 2021). Students with high expectations of success or who value schoolwork are more likely to engage in learning, even when faced with difficulties (Murayama et al., 2013). Conversely, mathematics anxiety, characterized by negative emotions such as fear and tension when faced with mathematics (Ahmed et al., 2013; Ashcraft & Krause, 2007), can hinder learning and performance and lead to avoidance of mathematical tasks (Barron & Hulleman, 2015; Chinn, 2009; Namkung et al., 2019; Ramirez et al., 2016; Trezise & Reeve, 2014). Difficulties in mathematics can thus generate a vicious circle of anxiety, disengagement, and loss of self-confidence, and even lead to dropping out of school (Adihou, 2011; Astolfi & Develay, 2020). These theoretical considerations highlight the need to adopt a holistic approach to educational effectiveness, integrating not only cognitive dimensions but also motivational and affective dimensions. The present study takes this perspective, examining the relevance of six complementary indicators: attraction to mathematics, perceived usefulness of the discipline, perceived difficulty, expectations of success, self-efficacy, and mathematical anxiety. These elements are not only perceived as important outcomes in themselves (Seidel, 2008) but also constitute conditions conducive to learning (Fong et al., 2018; Govaerts & Grégoire, 2006; Gupta & Zheng, 2020; Holm et al., 2017; Krapp & Prenzel, 2011; Meyer & Turner, 2006). In this context, the central question of this research is: how can motivational and affective factors be relevant indicators of educational effectiveness in mathematics? More specifically,

1. Is there a relationship between student motivation, as reported by teachers, and their results, also identified by teachers?
2. What is the relationship between the motivation and the level of anxiety?
   2.1. Is there a statistically significant relationship between the motivational dimensions measured by the Math Profile scale and the level of anxiety in mathematics (ANXMAT)?
   2.2. What distinct motivational profiles can be identified among students based on the dimensions of the Math Profile scale?
   2.3. Does the level of mathematics anxiety differ according to the motivational profiles identified in the previous question?
3. Do the dimensions of motivation (Math Profile) and anxiety in mathematics (ANXMAT) vary according to the gender of the students ?

Theoretical Framework

The influence of motivational and emotional factors

The increased interest in this topic is partly due to the accumulation of evidence demonstrating the significant impact of emotions on learning processes and student performance in mathematics (Ahmed et al., 2013; Hanin & Van Nieuwenhoven, 2016). These factors influence, in particular, the choice of knowledge mobilized, the level of effort expended, and perseverance in the face of the task (Marcoux, 2014). Failure to complete a task can profoundly affect an individual's self-esteem and self-image, often leading to abandonment of that task (Peterson & Seligman, 2004). As Adihou (2011) points out, mathematics is particularly likely to elicit a variety of negative reactions in students, such as anxiety, lack of self-confidence and early dropout, among others. Furthermore, studies have shown that encountering difficulties, obstacles or dead ends contributes to eroding learners' beliefs in their personal effectiveness (Artino Jr., 2012; Hanin & Van Nieuwenhoven, 2018). This phenomenon highlights the crucial importance of an appropriate pedagogical approach aimed at strengthening students' resilience in the face of academic challenges. Furthermore, it diminishes their positive emotions (Tornare et al., 2015) and triggers negative emotions (Hanin & Van Nieuwenhoven, 2019; Holm et al., 2017). It should be noted that studies have shown that self-efficacy in mathematics is a significant predictor of performance, both among elementary school students (Frenzel et al., 2007; Govaerts & Grégoire, 2006; A. J. Martin, 2004) and secondary school students (Seaton et al., 2014; Usher & Pajares, 2009). The cognitive challenges faced by many learners often give rise to negative feelings toward mathematics, thereby hindering their learning process and success in this field (Artino Jr., 2012). Furthermore, Usher & Pajares (2009) have shown that a student's past performance is the most decisive factor in their perception of their mathematical abilities, and that students' mathematical performance is affected by their negative emotions (Mikolajczak et al., 2014). Studies suggest that positive emotional states promote academic performance in mathematics, while negative emotions such as anxiety, shame, or despair tend to hinder it (Frenzel et al., 2007; Pekrun, 2006).

Anxiety and its impact on academic performance

Anxiety associated with mathematics has a significant impact on academic performance, leading to lower test scores (Barroso et al., 2021; Caviola et al., 2022) and reduced learning ability (Vukovic et al., 2013). In addition, math anxiety is correlated with affective and motivational aspects such as lack of motivation (Wang et al., 2015), low self-esteem (Ahmed et al., 2013; Jameson & Fusco, 2014), and a diminished perception of competence (Goetz et al., 2013). The relationship between mathematics anxiety and performance is likely bidirectional, with anxiety causing a decline in academic performance, which in turn reinforces anxiety and disengagement (Carey et al., 2015). Furthermore, math anxiety disrupts cognitive functioning by diverting the learner's attention from the task at hand to negative thoughts and concerns, which can impact their performance in the subject (Ashcraft & Krause, 2007). Experiences of success and failure are essential to the formation of mathematical self-concept (Parker et al., 2018). Perceived competence is one of the most effective indicators for predicting success in mathematics (Seaton et al., 2014). Furthermore, it is more closely linked to emotions in mathematics classes than to the perceived value of the subject (Ahmed et al., 2013; Frenzel et al., 2007).

The influence of gender on emotional experience and motivation in mathematics

Significant differences between boys and girls have been identified in terms of their behavioral profiles (Hanin & Van Nieuwenhoven, 2019). Empirical studies reveal that emotional disparities between girls and boys in mathematics can be observed as early as primary school. Girls seem to be more prone to negative emotions such as anxiety, shame, or discouragement, while boys more often display positive emotions such as pride or pleasure (Frenzel et al., 2007; Pekrun, 2006). The study conducted by Hanin & Van Nieuwenhoven (2019) points in the same direction and indicates that young girls seem to adopt a more resigned or anxious attitude, while boys display a more positive mindset. In addition, a considerable proportion of boys expressed feelings of boredom, significantly higher than those observed in girls. These findings are consistent with previous research conducted on primary school students, indicating that girls experience more negative emotions and fewer positive emotions in relation to mathematics, and that they tend to underestimate their mathematical abilities compared to boys (Ahmed et al., 2013; Else-Quest et al., 2012; Frenzel et al., 2007; Wigfield et al., 2006). Girls also tend to place less value on mathematical activities (Frenzel et al., 2007; Wigfield et al., 2006). These differences may be related to distinct motivational beliefs: girls tend to underestimate their mathematical abilities and place less intrinsic value on this subject compared to boys (Pekrun, 2006). Furthermore, Hanin & Van Nieuwenhoven (2019) add that these gender differences can be attributed to two harmful stereotypes: girls are less gifted in mathematics than boys, and mathematics is an exclusively male field of study (Ambady et al., 2001; Frenzel et al., 2007). Additional studies have revealed that, regardless of their academic performance, good or bad, girls tend to be more affected by internal emotional distress than boys (A. J. Martin, 2004; Pomerantz et al., 2002). A significant increase in emotional differences between girls and boys is observed during adolescence (Else-Quest et al., 2012; Wigfield et al., 2006). This pivotal period seems to coincide with the emergence of more marked differences in the emotional experiences of the two sexes with regard to mathematics. Despite efforts to reduce gender inequalities, girls in secondary school often continue to experience a greater sense of discomfort than boys when it comes to mathematics (Morge, 2005).

Methodology

Self-administered questionnaires are a commonly used tool for measuring non-cognitive concepts (Grützmacher et al., 2021). To access beliefs, attitudes, conceptions, representations, and opinions, participant verbalization is essential because these elements are not directly observable (Giroux & Tremblay, 2009). Self-assessment has undeniable advantages for measuring latent variables, including ease of interpretation and rapid and economical administration (Raccanello et al., 2022).

The Math Profile: a tool for measuring motivation in mathematics

This tool, derived from previous work demonstrating satisfactory reliability and validity (Beal et al., 2006, 2008, 2010; Beal & Stevens, 2007; Boekaerts, 2002; Cohen et al., 2008; Eccles et al., 1993), has been integrated into a Moodle environment. The Math Profile is an online self-assessment tool that explores various aspects of mathematical motivation, including self-efficacy, perceived usefulness of mathematics, appeal of the subject, expectations of success, and perception of the relative difficulty of mathematics. Two items are associated with each dimension, and an average score is then calculated for each dimension. Students are asked to rate each item on a 5-point Likert scale. The reliability of the scale was assessed using McDonald's omega coefficient, which revealed acceptable internal consistency ($\omega = .727$).

The instrument for measuring anxiety in mathematics: the ANXMAT scale

Inspired by the work of Özcan & Eren Gümüş (2019), we also used the ANXMAT scale, a validated instrument consisting of five items from the 2012 and 2003 PISA surveys (OECD, 2014). Lee's (2009) study showed that these items constituted a single construct representing anxiety in mathematics. The ANXMAT scale uses a 4-point Likert scale (1 = strongly agree; 4 = strongly disagree) to measure students' anxiety about mathematics. The reliability of the ANXMAT scale was assessed using McDonald's omega, obtaining a value of 0.749, which suggests satisfactory internal consistency of the items measured in this study.

Data collection tools: from the teachers' perspective

Mathematics teachers assessed their students' motivation and performance using an online questionnaire (Google Forms). The assessment of motivation was based on a three-level scale inspired by the work of Beal and colleagues (2008): (a) high motivation, characterized by active participation in class, completion of all homework assignments, a keen interest in mathematics, and academic success; (b) average motivation; and (c) low motivation, identified by frequent failure to complete homework assignments, lack of participation and attendance in class, and disinterest in mathematics and academic performance. The results were classified into three categories: (a) high achievement, determined by performance above grade-level expectations; (b) average achievement, characterized by performance in line with expectations; and (c) low achievement, defined by performance below expectations, with the latter category indicating a risk of failure in mathematics. It should be noted, however, that this categorisation is based on expectations regarding academic achievement, which may vary depending on institutional contexts and the assessment practices of individual teachers. Because this approach reflects standard educational norms, it should therefore be interpreted as a contextualised estimate of performance rather than an absolute measure of mathematical ability.

Sample

The study was conducted among 1,228 first-year secondary school students (aged 12) from 21 secondary schools in French-speaking Belgium. The sample was constituted using a non-probabilistic sampling technique characterized by non-random selection of participants (Gumuchian & Marois, 2000), of the voluntary type (Hascoët et al., 2024). Participants were included in the study based on their motivation to contribute to the research and their willingness to participate in the protocol, resulting in a sample of committed students and teachers.

Analysis of Results

Relationship between student performance and motivation

An examination of the contingency table (see Table 1) reveals several significant trends. Firstly, 66% of pupils with low motivation in mathematics also achieve results that are considered poor by their teachers, while only 2% of them achieve performance levels above expectations for their school level. Secondly, pupils whose motivation is assessed as average are mainly distinguished by their average results (66%). Thirdly, among highly motivated pupils, one in two achieves results above expectations. Finally, pupils identified as motivated account for 88% of all high results, compared with only 0.6% for pupils with low motivation. These findings suggest a positive association between motivation in mathematics and academic performance as perceived by teachers, although they do not establish a causal relationship.

A chi-square test ($X^2 = 444.198$; df = 4; $p < .001$) confirms the existence of a statistically significant association between teacher-reported student motivation and student performance as perceived by teachers.

Analysis of the links between motivation, anxiety, and student performance

Spearman's correlation analyses revealed several highly significant relationships between the variables studied ($p <.001$), confirming the trends reported in the literature. Mathematical self-efficacy shows a strong positive correlation with expected success in mathematics ($\rho = .734$), indicating that students who feel competent

Table 1

Student motivation and student achievement as reported by teachers

Motivation		Result			Total
		Poor results	Average results	High results	
Low motivation	Number	85	42	2	129
	% lines	65.891 %	32.558 %	1.550 %	100.000 %
	% columns	41.463 %	7.850 %	0.625 %	12.170 %
Average motivation	Number	102	263	35	400
	% lines	25.500 %	65.750 %	8.750 %	100.000 %
	% columns	49.756 %	49.159 %	10.938 %	37.736 %
High motivation	Number	18	230	283	531
	% lines	3.390 %	43.315 %	53.296 %	100.000 %
	% columns	8.780 %	42.991 %	88.438 %	50.094 %
Total	Number	205	535	320	1060
	% lines	19.340 %	50.472 %	30.189 %	100.000 %
	% columns	100.000 %	100.000 %	100.000 %	100.000 %

in mathematics also anticipate positive results in this subject. In addition, self-efficacy is negatively correlated with perceived difficulty (p = –.630) and with anxiety in mathematics (p = –.556). A moderate positive correlation is also observed between students' self-efficacy in mathematics and their enjoyment of mathematics (p = .531). Although this relationship is weaker than the previous ones, self-efficacy is positively correlated with the perception of the usefulness of mathematics (p = .326). A negative correlation is observed between expectations of success and perceived difficulty (p = –.54), as well as between expectations of success and mathematics anxiety (p = –.55). These results indicate that students who expect to succeed in mathematics tend to perceive the subject as less difficult and experience less anxiety. Expected success is also positively correlated with enjoying mathematics (p = .452). Perceived difficulty in mathematics is positively correlated with anxiety in mathematics (p = .500), suggesting that students who find mathematics difficult tend to experience more anxiety. Furthermore, a negative correlation was observed with interest in mathematics (p = –.508), showing that students who experience more difficulty in mathematics enjoy the subject less. The perceived usefulness of mathematics by students is positively correlated with interest in mathematics (p = .478), indicating that students who perceive mathematics as useful enjoy it more. However, it should be noted that perceived usefulness is weakly correlated with anxiety in mathematics (p = –.174). We also find that the more students enjoy mathematics, the less anxiety they experience (p = –.330).

Using the K-means clustering method, we grouped students according to the five variables from the Math Profile scale. The optimal number of clusters appears to be four, as adding a fifth cluster does not significantly reduce intra-class inertia. The K-Means algorithm converged after 15 iterations, with zero residual variations between cluster centers. This convergence shows that the cluster centers have stabilized and that the clusters obtained are robust and well defined. The minimum distance between the initial centers was 4.61, indicating good separation between clusters from the outset. The relatively homogeneous size of the groups ensures that the results are not dominated by a single cluster, thus increasing the robustness of the analysis (see Table 2). The centers of the final clusters highlight four distinct groups of students according to the dimensions of the "Math Profile" scale, providing a typology of student profiles in relation to mathematics.

These results show that the four clusters identified capture a variety of student profiles, ranging from students who are highly engaged and confident in mathematics to those who feel challenged and less inclined to enjoy it. Thus, cluster 1 represents the most motivated and confident students, while cluster 2 includes those who experience difficulties and are unmotivated. Clusters 3 and 4 offer intermediate profiles, with students possessing moderate confidence and perception of usefulness. However, cluster 4 stands out for its greater appreciation of mathematics. These results offer interesting avenues for tailored educational interventions, particularly to support students in cluster 2 and reinforce the motivation of students in the intermediate clusters.

An ANOVA reveals a significant effect of cluster membership on mathematics anxiety ($F(3, 1226) = 183.71$; $p < .001$). In addition, the effect size ($\omega^2 = .308$) indicates that

Table 2
Final cluster center

	1 : High-achieving and confident students N = 314	2 : Discouraged and disengaged students in difficulty N = 292	3 : Moderately confident and uninterested students N = 267	4 : Students motivated despite difficulties N = 357
Self-efficacy in mathematics	4.3	2.2	3.4	3.0
Expected success in mathematics	4.3	2.5	3.6	3.3
Difficulty in mathematics	2.0	3.6	2.8	2.9
The usefulness of mathematics	4.1	3.2	3.2	3.9
Interest in mathematics	4.3	2.2	2.5	3.8

approximately 30.8% of the variance observed in mathematics anxiety is attributable to cluster membership, reflecting a moderate to strong effect. The differences in mean values (M, here representing the mean anxiety scores for each cluster) show that cluster 1 consistently has significantly lower anxiety levels than the other clusters. The differences are particularly marked with cluster 2 ($t = -22.901$; $p_{Tukey} < .001$ and $M = -0.970$), which has the highest anxiety levels ($M_{Anxiety\_Cluster2} = 2.749$). Significant differences were also observed between cluster 1 and clusters 3 ($t = –7.080$; $p_{Tukey} < .001$ and $M = –.307$) and 4 ($t = –12.831$; $p_{Tukey} <.001$ and $M = –0.517$), confirming that cluster 1 is distinguished by particularly low anxiety levels ($M_{Anxiety\_Cluster1} = 1.779$). Cluster 2, with the highest average anxiety level, is significantly different from cluster 3 ($t = 15.027$; $p_{Tukey} <.001$ and $M = 0.663$) and cluster 4 ($t = 11.015$; $p_{Tukey} < .001$ and $M = 0.453$), suggesting significant heterogeneity in anxiety levels within the groups. In addition, a statistically significant difference was also found between cluster 3 ($M_{Anxiety\_Cluster3} = 2.086$) and cluster 4 ($t = –4.985$; $p_{Tukey} < .001$ and $M = –0.210$; $M_{Anxiety\_Cluster4} = 2.296$).

Influence of gender on motivation and anxiety

Boys (M = 3.310) display significantly higher self-efficacy than girls (M = 3.050) (W = 184,142.5; $p < .001$). This result suggests that boys have greater confidence in their ability to perform mathematics-related tasks. Similarly, boys (M = 3.535) have higher expectations of success than girls (M = 3.296) (W = 185,564; $p < .001$). This finding reflects boys' more positive perception of their potential for success in mathematics. In addition, they (M = 3.374) are also more attracted to mathematics than girls (M = 3.114) (W = 188554; $p < .001$). This perception is probably reinforced by the usefulness they attribute to mathematics (M = 3.697) compared to girls' perception of this subject (M = 3.519) (W = 189365.5; $p < .001$). Girls, on the other hand, report more difficulties in mathematics (M = 2.933) than boys (M = 2.776) (W = 243,753; $p < .001$). These results show that girls perceive mathematics as a more complex subject than boys. They are also significantly more anxious about mathematics (M = 2.374) than boys (M = 2.131) (W = 269,761; $p < .001$).

Discussion

The school's mission is not only to impart knowledge, but also to promote the development of students' social and emotional skills (Fend, 2009). With this in mind, it seems essential to carefully examine the many factors that influence students' attitudes toward mathematics in order to provide appropriate support and promote their success.

Our results confirm the existence of a significant association between teachers' perceived motivation and academic performance in mathematics. Students considered to be low in motivation are mostly found in the low-performance category, while those perceived as highly motivated stand out with results above expectations. This correspondence between motivation and performance highlights the relevance of teachers' observations in understanding student engagement and is consistent with the work of Beal et al. (2008) on the link between observable motivation and academic success.

Difficulties encountered in mathematics can lead to anxiety, loss of confidence, and avoidance strategies (Adihou, 2011; Focant, 2021). Fear of making mistakes, often the source of mathematical anxiety, creates a vicious cycle of disengagement (Astolfi & Develay, 2020). These negative emotions disrupt students' emotional balance and hinder their motivation to learn (Hanin & Van Nieuwenhoven, 2019; Holm et al., 2017; Meyer & Turner, 2006).

Correlation analyses confirm the importance of students' beliefs about their skills and emotions when it comes to mathematics (Ahmed et al., 2013; Cosnefroy, 2011). Self-efficacy appears to be a key factor: it is positively correlated with expected success, but negatively correlated with perceived difficulty and anxiety. These results corroborate the work of Frenzel et al. (2007) and Usher & Pajares (2009), according to which feelings of competence directly influence expectations of success and perseverance. Confident students perceive mathematics as more accessible and engage more in tasks, while those who doubt their abilities tend to avoid challenges, thus limiting their learning opportunities (Fong et al., 2018).

The negative correlation observed between perceived difficulty and anxiety confirms that the perception of mathematical complexity is a significant barrier to learning (Marcoux, 2014). Students in cluster 2, identified as discouraged and struggling, have the highest levels of anxiety, while those in cluster 1, who are high-performing and confident, have low levels of anxiety. These results are consistent with the findings of Xiao & Sun (2021) and reinforce the idea that emotional regulation is an essential lever for success (Depaepe et al., 2015; Hanin & Van Nieuwenhoven, 2019, 2020). Motivation, on the other hand, seems to partially mitigate the harmful effects of mathematics anxiety, particularly among students in cluster 4, who are motivated despite the difficulties and compensate for stress with increased engagement (Justicia-Galiano et al., 2017).

With regard to gender, the results confirm marked differences in perceptions and emotions associated with mathematics (Frenzel et al., 2007; Parker et al., 2018). Boys exhibit higher self-efficacy and expectations of success than girls, which is consistent with the literature on gender-differentiated self-confidence (Ahmed et al., 2013; Else-Quest et al., 2012). These differences could be explained by the persistence of stereotypes associating mathematical skills with masculinity (Ambady et al., 2001; Wigfield et al., 2006) and by certain teacher evaluation biases, which tend to underestimate high-performing girls (Lafontaine & Monseur, 2009). Although girls recognize the usefulness of mathematics, they more often perceive it as difficult (Hanin & Van Nieuwenhoven, 2019), which fuels their anxiety and can hinder their engagement.

Mathematics anxiety, which is higher among girls, is a documented risk factor for academic success (Ahmed et al., 2013; Barroso et al., 2021). This difference could result from greater internalization of emotional distress (Pomerantz et al., 2002) and increased expression of negative emotions (Frenzel et al., 2007). Adolescence amplifies these emotional differences (Morge, 2005; Wigfield et al., 2006), a period when girls express more apprehension and discomfort with the subject.

The results of this study invite further exploration of the concept of self in mathematics, whose fragility makes it particularly sensitive to experiences of failure and cognitive obstacles encountered during learning. These difficulties, by generating negative emotions, can alter students' motivation, perseverance, and ultimately their success (Kramarski et al., 2010; Tzohar-Rozen & Kramarski, 2014). It therefore seems essential to better understand the role of experiences of success and failure in the construction of mathematical self-efficacy, i.e., a student's belief in their ability to succeed in this discipline (Parker et al., 2018).

With this in mind, future research could explore the educational and emotional conditions that promote the development of a strong sense of competence, particularly in difficult situations. Particular attention should be paid to psychological support interventions aimed at boosting self-confidence and regulating mathematics anxiety, especially among girls, who are more vulnerable to these negative emotions (Barroso et al., 2021). Several studies have demonstrated the effectiveness of emotional regulation techniques such as relaxation (Brunyé et al., 2013; Segool et al., 2013) and mindfulness, whose benefits in reducing school anxiety are increasingly well documented (Bautista, 2023; Burke, 2010).

It would also be appropriate to engage in in-depth reflection on how mathematics teaching practices can incorporate explicit strategies to combat gender stereotypes (Lafontaine & Monseur, 2009). In this context, Morin-Messabel (2014) emphasizes the need for a proactive approach by teachers, consisting of clearly stating that mathematical skills do not depend on gender, but on the development of cognitive strategies and individual effort. This stance could help to change the social representations associated with mathematical success and encourage a more equitable engagement between girls and boys.

In addition, self-efficacy can be undermined by repeated learning experiences that are perceived as solitary or unrewarding, such as solving complex problems individually. Adihou (2011) shows that this type of approach, by causing apprehension and cognitive isolation, tends to increase anxiety and weaken perceptions of competence. In this regard, the results of the PISA program (2017), which focuses on collaborative problem solving, offer promising prospects: girls outperform boys in all participating countries, which could be explained by their more developed interpersonal skills and a stronger orientation toward cooperation and collective success.

However, the gender composition of learning groups influences participation and anxiety dynamics. Dasgupta et al. (2015) show that girls who are in the minority in a male-dominated group participate less actively and show greater anxiety. These findings highlight the importance of designing inclusive learning environments that are attentive to diversity and gender balance in order to foster a safe and stimulating emotional climate for all.

Promoting an equitable educational culture, where girls and boys feel equally legitimate and encouraged to engage in scientific disciplines, is a key challenge in reducing gender disparities in academic performance and strengthening all students' engagement with mathematics. Future research could therefore examine: the effects of mixed collaborative arrangements on reducing anxiety and strengthening motivation, the role of teacher training in recognizing and deconstructing gender stereotypes, and the long-term impact of emotional regulation programs (mindfulness, relaxation, psycho-educational support) on self-concept and success in mathematics.

References

Adihou, A. (2011). Enseignement-apprentissage des mathématiques et souffrance à l'école. *Les Collectifs du Cirp, 2*, 90-102. https://www.cirp.uqam.ca/documents%20pdf/collectifs/10_Adihou_A.pdf

Ahmed, W., van der Werf, G., Kuyper, H., & Minnaert, A. (2013). Emotions, self-regulated learning, and achievement in mathematics: A growth curve analysis. *Journal of Educational Psychology, 105(*1), 150-161. https://doi.org/10.1037/a0030160

Ambady, N., Shih, M., Kim, A., & Pittinsky, T. L. (2001). Stereotype Susceptibility in Children: Effects of Identity Activation on Quantitative Performance. *Psychological Science, 12*(5), 385-390. https://doi.org/10.1111/1467-9280.00371

Antunes, C., & Fontaine, A. M. (2007). Gender differences in the causal relation between adolescents'maths self-concept and scholastic performance. *Psychologica Belgica, 47*(1), 71-94. https://doi.org/10.5334/pb-47-1-71

Artino Jr., A. R. (2012). Academic self-efficacy: From educational theory to instructional practice. *Perspectives on Medical Education, 1*(2), 76-85. https://doi.org/10.1007/S40037-012-0012-5

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*(2), 243-248. https://doi.org/10.3758/BF03194059

Astolfi, J.-P., & Develay, M. (2020). *L'erreur, un outil pour enseigner* (13e éd). ESF sciences humaines.

Barron, K. E., & Hulleman, C. S. (2015). Expectancy-Value-Cost Model of Motivation. In J. Wright (Ed.), *International Encyclopedia of the Social & Behavioral Sciences* (p. 503-509). Elsevier.

Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin, 147*(2), 134-168. https://doi.org/10.1037/bul0000307

Bautista, C. A. (2023). Reducing mathematics anxiety in the classroom. *Teachers and Curriculum, 23*(1), 79-88. https://doi.org/10.15663/tandc.v23i1.427

Beal, C., & Stevens, R. (2007). Student Motivation and Performance in Scientific Problem Solving Simulations. In M. Ellison (Ed.), *Proceedings of Artificial intelligence in education* (539-541). Association for the Advancement of Artificial Intelligence.

Beal, C., Adams, N. M., & Cohen, P. R. (2010). Reading Proficiency and Mathematics Problem Solving by High School English Language Learners. *Urban Education, 45*(1), 58-74. https://doi.org/10.1177/0042085909352143

Beal, C., Qu, L., & Lee, H. (2006). Classifying Learner Engagement through Integration of Multiple Data Sources. In M. Ellison (Ed.), *Proceedings of the AAAI Conference on Artificial Intelligence* (vol. 21, 151-156). Association for the Advancement of Artificial Intelligence.

Beal, C., Qu, L., & Lee, H. (2008). Mathematics motivation and achievement as predictors of high school students' guessing and help-seeking with instructional software. *Journal of Computer Assisted Learning, 24*(6), 507-514. https://doi.org/10.1111/j.1365-2729.2008.00288.x

Boekaerts, M. (2002). The on-line motivation questionnaire: A self-report instrument to assess students' context sensitivity. In P. R. Pintrich & M. L. Maehr (Eds.), *Advances in Motivation and Achievement* (vol. 12, p. 77-120). Elsevier Science.

Brunyé, T. T., Mahoney, C. R., Giles, G. E., Rapp, D. N., Taylor, H. A., & Kanarek, R. B. (2013). Learning to relax : Evaluating four brief interventions for overcoming the negative emotions accompanying math anxiety. *Learning and Individual Differences, 27*, 1 7. https://doi.org/10.1016/j.lindif.2013.06.008

Burke, C. A. (2010). Mindfulness-Based Approaches with Children and Adolescents : A Preliminary Review of Current Research in an Emergent Field. *Journal of Child and Family Studies, 19*(2), 133 144. https://doi.org/10.1007/s10826-009-9282-x

Carey, E., Hill, F., Devine, A., & Szücs, D. (2015). The Chicken or the Egg? The Direction of the Relationship Between Mathematics Anxiety and Mathematics Performance. *Frontiers in Psychology, 6*, 1-6. https://doi.org/10.3389/fpsyg.2015.01987

Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J. M., Szűcs, D., & Mammarella, I. C. (2022). Math Performance and Academic Anxiety Forms, from Sociodemographic to Cognitive Aspects: A Meta-analysis on 906,311 Participants. *Educational Psychology Review, 34*(1), 363-399. https://doi.org/10.1007/s10648-021-09618-5

Chinn, S. (2009). Mathematics anxiety in secondary students in England. *Dyslexia, 15*(1), 61-68. https://doi.org/10.1002/dys.381

Cohen, P. R., Beal, C., & Adams, N. M. (2008). The Design, Deployment and Evaluation of the AnimalWatch Intelligent Tutoring System. *Frontiers in Artificial Intelligence and Applications, 178*, 663-667. https://doi.org/10.3233/978-1-58603-891-5-663

Cosnefroy, L. (2011). *Apprentissage autorégulé – Entre cognition et motivation.* PUG.

Dasgupta, N., Scircle, M. M., & Hunsinger, M. (2015). Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proceedings of the National Academy of Sciences, 112*(16), 4988 4993. https://doi.org/10.1073/pnas.1422822112

Depaepe, F., De Corte, E., & Verschaffel, L. (2015). Students' Non-realistic Mathematical Modeling as a Drawback of Teachers' Beliefs About and Approaches to Word Problem Solving. In B. Pepin & B. Roesken-Winter (Éds.), *From beliefs to dynamic affect systems in mathematics education: Exploring a mosaic of relationships and interactions* (p. 137-156). Springer International Publishing.

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and Gender Differences in Children's Self- and Task Perceptions during Elementary School. *Child Development, 64*(3), 830-847. https://doi.org/10.2307/1131221

Else-Quest, N. M., Higgins, A., Allison, C., & Morton, L. C. (2012). *Gender differences in self-conscious emotional experience: A meta-analysis. Psychological Bulletin, 138*(5), 947-981. https://doi.org/10.1037/a0027930

Fagnant, A., Demonty, I., Dierendonck, C., Dupont, V., & Marcoux, G. (2014). Chapitre 11. Résolution de tâches complexes, évaluation « en phases » et compétence en mathématiques. In C. Dierendonck, E. Loarer et B. Rey (Eds.), *L'évaluation des compétences en milieu scolaire et en milieu professionnel* (p. 179-189). De Boeck Supérieur.

Fend, H. (2009). *Neue Theorie der Schule.* VS Verlag für Sozialwissenschaften.

Fernández-Villaverde, J., Guerrón-Quintana, P., Kuester, K., & Rubio-Ramírez, J. (2015). Fiscal Volatility Shocks and Economic Activity. *American Economic Review, 105*(11), 3352-3384. https://doi.org/10.1257/aer.20121236

Focant, J. (2021). Impact des capacités d'autorégulation en résolution de problèmes chez les enfants de 10 ans. *Éducation et francophonie, 31*(2), 45-64. https://doi.org/10.7202/1079587ar

Fong, C. J., Acee, T. W., & Weinstein, C. E. (2018). A Person-Centered Investigation of Achievement Motivation Goals and Correlates of Community College Student Achievement and Persistence. *Journal of College Student Retention: Research, Theory & Practice, 20*(3), 369-387. https://doi.org/10.1177/1521025116673374

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics - A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education, 22*(4), 497. https://doi.org/10.1007/BF03173468

Giroux, S., & Tremblay, G. (2009). *Méthodologie des sciences humaines: La recherche en action* (3e éd.). ERPI.

Goetz, T., Bieg, M., Lüdtke, O., Pekrun, R., & Hall, N. C. (2013). Do girls really experience more anxiety in mathematics? *Psychological Science, 24*(10), 2079-2087. https://doi.org/10.1177/0956797613486989

Govaerts, S., & Grégoire, J. (2006). Chapitre 8. Motivation et émotions dans l'apprentissage scolaire. In B. Galand et E. Bourgeois (Eds.), *(Se) motiver à apprendre* (p. 97-106). Presses Universitaires de France.

Grützmacher, L., Vieluf, S., & Hartig, J. (2021). Are questionnaire scales which measure non-cognitive constructs suitable as school effectiveness criteria? A measurement invariance analysis. *School Effectiveness and School Improvement, 32*(3), 430-447. https://doi.org/10.1080/09243453.2021.1903511

Gumuchian, H., & Marois, C. (2000). *Initiation à la recherche en géographie: Aménagement, développement territorial, environnement.* Presses de l'Université de Montréal.

Gupta, U., & Zheng, R. Z. (2020). Cognitive Load in Solving Mathematics Problems: Validating the Role of Motivation and the Interaction Among Prior Knowledge, Worked Examples, and Task Difficulty. *European Journal of STEM Education, 5*(1), 2-14. https://doi.org/10.20897/ejsteme/9252

Hanin, V., & Van Nieuwenhoven, C. (2016). Evaluation d'un dispositif pédagogique visant le développement de stratégies cognitives et métacognitives en résolution de problèmes au grade 7. Evaluer. *Journal International de Recherche En Education et Formation, 2*(1), 53-88. https://dial.uclouvain.be/pr/boreal/object/boreal:180716

Hanin, V., & Van Nieuwenhoven, C. (2018). Évaluation d'un dispositif d'enseignement-apprentissage en résolution de problèmes mathématiques: Évolution des comportements cognitifs, métacognitifs, motivationnels et émotionnels d'un résolveur novice et expert. *Évaluer. Journal international de recherche en éducation et formation, 4*(1), 37-66. https://journal.admee.org/index.php/ejiref/article/view/98/82

Hanin, V., & Van Nieuwenhoven, C. (2019). Emotional and motivational relationship of elementary students to mathematical problem-solving: A person-centered approach. *European Journal of Psychology of Education, 34*(4), 705-730. https://doi.org/10.1007/s10212-018-00411-7

Hanin, V., & Van Nieuwenhoven, C. (2020). An Exploration of the Cognitive, Motivational, Emotional and Regulatory Behaviours of Elementary-School Novice and Expert Problem Solvers. *Canadian Journal of Science, Mathematics and Technology Education, 20*(2), 312-341. https://doi.org/10.1007/s42330-020-00092-9

Hascoët, M., Lepareur, C., & Lima, L. (2024). *Méthodes de recherche en sciences humaines et sociales: Fiches synthétiques - Exemples commentés - Conseils pratiques et outils d'accompagnement* (1re éd.). De Boeck Supérieur.

Holm, M. E., Hannula, M. S., & Björn, P. M. (2017). Mathematics-related emotions among Finnish adolescents across different performance levels. *Educational Psychology, 37*(2), 205-218. https://doi.org/10.1080/01443410.2016.1152354

Jameson, M. M., & Fusco, B. R. (2014). Math anxiety, math self-concept, and math self-efficacy in adult learners compared to traditional undergraduate students. *Adult Education Quarterly, 64*(4), 306-322. https://doi.org/10.1177/0741713614541461

Krapp, A., & Prenzel, M. (2011). Research on Interest in Science: Theories, methods, and findings. *International Journal of Science Education, 33*(1), 27-50. https://doi.org/10.1080/09500693.2010.518645

Kramarski, B., Weisse, I., & Kololshi-Minsker, I. (2010). How can self-regulated learning support the problem solving of third-grade students with mathematics anxiety? *ZDM, 42*(2), 179 193. https://doi.org/10.1007/s11858-009-0202-8

Lafontaine, D., & Monseur, C. (2009). Les évaluations des performances en mathématiques sont-elles influencées par le sexe de l'élève? *Mesure et évaluation en éducation, 32*(2), 71 98. https://doi.org/10.7202/1024955ar

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*(3), 355-365. https://doi.org/10.1016/j.lindif.2008.10.009

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: A longitudinal panel analysis. *Journal of Adolescence, 27*(2), 165-179. https://doi.org/10.1016/j.adolescence.2003.11.003

Marcoux, G. (2014). Résolution de problèmes arithmétiques dans le cadre d'une approche par compétences: Ordre des tâches et parts d'influence de quelques facteurs cognitifs et motivationnels. *Cahiers des Sciences de l'Éducation, 36*, 67-114. https://www.aspe.uliege.be/upload/docs/application/pdf/2022-05/4._marcoux__pp._67_114_.pdf

Marsh, H. W., & O'Mara, A. J. (2010). Long-Term Total Negative Effects of School-Average Ability on Diverse Educational Outcomes: Direct and Indirect Effects of the Big-Fish-Little-Pond Effect. *Zeitschrift für Pädagogische Psychologie, 24*(1), 51-72. https://doi.org/10.1024/1010-0652/a000004

Martin, A. J. (2004). School motivation of boys and girls: Differences of degree, differences of kind, or both? *Australian Journal of Psychology*, *56*(3), 133-146. https://doi.org/10.1080/00049530412331283363

Meyer, D. K., & Turner, J. C. (2006). Re-conceptualizing emotion and motivation to learn in classroom contexts. *Educational Psychology Review, 18*(4), 377-390. https://doi.org/10.1007/s10648-006-9032-1

Mikolajczak, M., Quoidbach, J., Kotsou, I., & Nelis, D. (2014). *Les compétences émotionnelles.* Dunod.

Morin-Messabel, C. (2014). Applications de la psychologie sociale : La thématique du genre en éducation. *Revue électronique de psychologie sociale, 6*, 24 33. https://psychologiescientifique.org/wp-content/uploads/2018/02/REPS6.pdf

Morge, S. (2005). High school students' math beliefs and society. *Academic Exchange Quarterly, 9*(3), 182-187.

Murayama, K., Pekrun, R., Lichtenfeld, S., & Vom Hofe, R. (2013). Predicting Long-Term Growth in Students' Mathematics Achievement: The Unique Contributions of Motivation and Cognitive Strategies. *Child Development, 84*(4), 1475-1490. https://doi.org/10.1111/cdev.12036

Namkung, J. M., Peng, P., & Lin, X. (2019). The Relation Between Mathematics Anxiety and Mathematics Performance Among School-Aged Students: A Meta-Analysis. *Review of Educational Research, 89*(3), 459-496. https://doi.org/10.3102/0034654319843494

Özcan, Z. Ç., & Eren Gümüş, A. (2019). A modeling study to explain mathematical problem-solving performance through metacognition, self-efficacy, motivation, and anxiety. *Australian Journal of Education, 63*(1), 116-134. https://doi.org/10.1177/0004944119840073

Parker, P. D., Van Zanden, B., & Parker, R. B. (2018). Girls get smart, boys get smug: Historical changes in gender differences in math, literacy, and academic social comparison and achievement. *Learning and Instruction, 54*, 125-137. https://doi.org/10.1016/j.learninstruc.2017.09.002

Pekrun, R. (2006). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. *Educational Psychology Review, 18*(4), 315-341. https://doi.org/10.1007/s10648-006-9029-9

Peterson, C., & Seligman, M. (2004). *Character Strengths and Virtues: A Handbook and Classification*. Oxford University Press Inc.

Pomerantz, E. M., Altermatt, E. R., & Saxon, J. L. (2002). Making the grade but feeling distressed: Gender differences in academic performance and internal distress. *Journal of Educational Psychology, 94*(2), 396-404. https://doi.org/10.1037/0022-0663.94.2.396

Raccanello, D., Brondino, M., Crescentini, A., Castelli, L., & Calvo, S. (2022). A brief measure for school-related achievement emotions: The achievement Emotions Adjective List for secondary students. *European Journal of Developmental Psychology, 19*(3), 458-476. https://doi.org/10.1080/17405629.2021.1898940

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology, 141*, 83-100. https://doi.org/10.1016/j.jecp.2015.07.014

Schiefele, U., Schaffner, E., Möller, J., & Wigfield, A. (2012). Dimensions of Reading Motivation and Their Relation to Reading Behavior and Competence. *Reading Research Quarterly, 47*(4), 427-463. https://doi.org/10.1002/RRQ.030

Seaton, M., Parker, P., Marsh, H. W., Craven, R. G., & Yeung, A. S. (2014). The reciprocal relations between self-concept, motivation and achievement: Juxtaposing academic self-concept and achievement goal orientations for mathematics success. *Educational Psychology, 34*(1), 49-72. https://doi.org/10.1080/01443410.2013.825232

Seidel, T. (2008). Stichwort: Schuleffektivitätskriterien in der internationalen empirischen Forschung. *Zeitschrift Für Erziehungswissenschaft, 11*(3), 348-367. https://doi.org/10.1007/s11618-008-0032-4

Segool, N. K., Carlson, J. S., Goforth, A. N., von der Embse, N., & Barterian, J. A. (2013). Heightened Test Anxiety Among Young Children: Elementary School Students' Anxious Responses to High-Stakes Testing. *Psychology in the Schools, 50*(5), 489 499. https://doi.org/10.1002/pits.21689

Tornare, E., Czajkowski, N. O., & Pons, F. (2015). Children's emotions in math problem solving situations: Contributions of self-concept, metacognitive experiences, and performance. *Learning and Instruction, 39*, 88-96. https://doi.org/10.1016/j.learninstruc.2015.05.011

Trezise, K., & Reeve, R. A. (2014). Working memory, worry, and algebraic ability. *Journal of Experimental Child Psychology, 121*, 120-136. https://doi.org/10.1016/j.jecp.2013.12.001

Tzohar-Rozen, M., & Kramarski, B. (2014). Metacognition, Motivation, and Emotions : Contribution of Self-Regulated Learning to Solving Mathematical Problems. *Global Education Review, 1*(4), 76 95. https://eric.ed.gov/?id=EJ1055263

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology, 34*(1), 89-101. https://doi.org/10.1016/j.cedpsych.2008.09.002

Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary Educational Psychology, 38*(1), 1-10. https://doi.org/10.1016/j.cedpsych.2012.09.001

Wang, Z., Lukowski, S. L., Hart, S. A., Lyons, I. M., Thompson, L. A., Kovas, Y., Mazzocco, M. M. M., Plomin, R., & Petrill, S. A. (2015). Is Math Anxiety Always Bad for Math Learning? The Role of Math Motivation. *Psychological Science, 26*(12), 1863-1876. https://doi.org/10.1177/0956797615602471

Wigfield, A., Eccles, J. S., Schiefele, U., Roeser, R. W., & Davis-Kean, P. (2006). Development of Achievement Motivation. In W. Damon, R. M. Lerner et N. Eisenberg. (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (vol. 3, 6e éd., p. 933-1002). John Wiley & Sons, Inc.

Xiao, F., & Sun, L. (2021). Students' Motivation and Affection Profiles and Their Relation to Mathematics Achievement, Persistence, and Behaviors. *Frontiers in Psychology, 11*, 1-15. https://doi.org/10.3389/fpsyg.2020.533593