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Students' Attitudes in Mathematics: When the Context Highlights the Importance of Emotions – A Secondary Publication

Philippe Genoud*

Center for Teacher Education for Secondary Schools, University of Fribourg, Fribourg, Switzerland

Corresponding author: Philippe Genoud, philippe.genoud@unifr.ch

Abstract: This article aims to gain a better understanding of how students' attitudes toward mathematical problem-solving operate. More specifically, it examines the extent to which these attitudes may play a different role depending on the context. To this end, we submitted two very similar golden rule math problems to 94 students in grade 10, once in the mathematics class and once in the French class. Our results are presented in three parts. First, in line with much other research, we highlight the significant gender differences in attitudes, with girls developing more negative and potentially deleterious attitudes to their learning. Second, we find significant links between various dimensions of attitudes (cognitive, affective, and behavioral) and students' academic achievement in mathematics. Finally, our analyses underline that in the context of the mathematics course, it is mainly anxiety that disturbs the success of the exercise, whereas the resolution of a very similar exercise is favored by positive emotions when it is inserted into a French worksheet. This suggests that students activate certain attitudes depending on the context – and in particular certain affects – which will have an impact on their performance. Such a result thus underlines the importance of emotions in learning and the way in which the context can induce them.

Keywords: Attitudes; Emotions; Mathematics; Context

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1. Introduction

Understanding the reasons why students engage in their learning has been a long-standing goal for educators and researchers. In this regard, the question of motivation is central to the teaching-learning process, and numerous approaches [1] propose various explanatory models to better understand this phenomenon. However, despite the multiplicity of research conducted on this topic – implemented in various contexts, with different measures, and among diverse samples – the issue of student engagement in learning activities remains lively in education.

The explanatory factors of this school engagement can be categorized into two groups. On one side are contextual aspects that characterize the environments in which learners find themselves. Among them, we can cite, for example, the social climate of the classroom, which concerns how students perceive the conditions under which learning takes place in terms of the quality of relationships, organization, and rules in place, as well as the dynamic regarding goal orientation. These different dimensions of the social climate play a significant role in student motivation [2]. Relatively close conceptually – but with dimensions that appeal more to students' anticipation of the consequences of their behaviors – the concept of psychological safety [3] also allows for a better understanding of student learning behaviors (or conversely, resistance to learning) within their class. It should be noted that these two concepts are considered partly as characteristics specific to the class group, but also as having an individual tone since each student, although immersed in the same context, apprehends the situation experienced in their own way. Contextual elements can also be found outside the school environment, notably in the influences at play within the family [4]. On the other side, there are more individual aspects that can be highlighted, such as the notion of controllability [5], feelings of competence [6], or targeted goals [7]. It is important to note that these two groups are not impermeable and that personal dispositions are partly shaped by the (school and family) contexts in which students evolve. Thus, a climate where the teacher tolerates teasing among students may lead them to avoid exposing themselves in class and gradually disengage from their learning [3].

These different explanatory factors of student motivation are generally taken into account through self-reported measures from students. Indeed, it is not so much the objective characteristics (e.g., the level of demonstrated competence or the actual control that the student can exert) that have an impact on behaviors, but rather the perceptions (by definition subjective) that the student develops regarding these different contextual and individual aspects. Thus, it is rather the feeling of being competent or the perception of being in a cooperative climate that will play a role in engagement in learning activities, as students are active interpreters of what happens in class and "respond" to what they perceive [8,9].

In this perspective, it is particularly interesting to examine how students perceive certain aspects of their school environment in order to better understand how learning is invested. Specifically, this research focuses more specifically on students' perception of the school subjects that are in their curriculum (in this case, mathematics and French) in order to examine their impact on their success.

1.1. Student attitudes toward learning

Among the numerous approaches to assessing how a student approaches the learning activities proposed to them, the notion of attitudes is particularly interesting because of the range of dimensions it covers. An attitude is an "internal state of the individual, resulting from the combination of perceptions, representations, emotions, experiences, and the analysis of their results. This internal state makes a determined behavior more or less probable in a given situation" [10]. Thus, while measures of motivation generally focus on cognitive or even conative aspects [11,12], attitudes incorporate these registers while also adding openness to dimensions of an affective nature [13]. These affective (or emotional) measures have been developed parallel to more cognitive models, especially in the context of learning mathematics. Some models clearly differentiate emotions from affects [14]. Indeed, while emotions are of marked intensity, of relatively short duration, and it is possible to identify the triggering stimulus, affects are more diffuse and notably encompass preferences and moods. However, in this publication, we consider the term "emotion" in its broadest sense, namely, that which includes all affective states (with positive or negative valence) that can be considered according to varied durations and intensities [15]. Indeed, numerous tools have focused on the anxiety developed by students in learning this discipline [16,17] due to its potential to generate very different profiles, particularly in terms of affects. Other tools have proposed the addition of measures of positive affects [18-20] to take into account that some students may experience pleasure or pride in their learning.

However, even though they are clearly less numerous than questionnaires assessing only anxiety in the face of learning, there are tools that rely on the attitude model by proposing dimensions in cognitive, affective, and conative registers [21-23], with the different dimensions sometimes being amalgamated into a single measure [24]. Cognitive aspects refer to the beliefs, knowledge acquisition, or representations that the student has about learning in the discipline in question. The affective register encompasses pleasant or unpleasant feelings as well as perceptions of being able to regulate the emotions generated by learning. Finally, the conative register can sometimes be limited to intentions (or tendencies to act) or propose a self-evaluation of behaviors as such (this is then referred to as a behavioral register). These registers – encompassing various dimensions – are relatively well delimited without being independent of each other. Indeed, numerous research studies [25] highlight correlations between dimensions and discuss their articulation.

1.2. The impact of attitudes on student performance

The extent to which attitudes can influence students' outcomes in a given domain remains difficult to ascertain due to the heterogeneous results of numerous studies on the subject. Analyses, such as those conducted by Papanastasious [26] based on TIMMS data from three countries with significant cultural differences (Cyprus, Japan, and the United States), highlight that attitudes (primarily measured through affective aspects) can predict mathematics performance. A meta-analysis published in the Journal for Research in Mathematics Education [27], encompassing over a hundred independent studies, yields more nuanced results. While acknowledging the lack of consensus in study results in the field, the authors assert that the links between attitudes and mathematics achievement are nevertheless present (and clearly significant). However, these links remain relatively weak as evidenced by the effect sizes presented. Moreover, while no clear difference is highlighted between girls and boys, the level of education seems to play a role as effect sizes are slightly more pronounced in secondary grades than in primary or tertiary ones.

By examining in more detail the results of research that takes into account measures corresponding to specific dimensions of attitudes (rather than the concept as a whole), we can distinguish between those concerning the cognitive register and those related to the affective register. In the former case, it is mainly the sense of competence that is linked to students' outcomes. Indeed, the self-assessment that students make of their competence level in a subject (referred to as the sense of competence) predicts their motivation for learning. On the other hand, self-efficacy (which is a student's self-assessment of their ability to succeed in a specific task presented to them) is indeed linked to the outcome obtained, while the sense of competence (corresponding to a broader self-assessment of their competence in a subject) predicts students' motivation in the task [28], which in turn impacts outcomes. This observation is also emphasized by Chouinard *et al.* [29], who note that a student's sense of competence – along with perceived utility – affects their efforts, particularly through the mastery goals they develop. PISA data has also highlighted such links. In a sizable sample (over 250,000 subjects), Lee and Stankov [31] constructed a correlation matrix based on fifteen measures. Three of these moderately to strongly correlate with student outcomes. Specifically, two of these dimensions relate to student perceptions (in the cognitive register: self-efficacy and sense of competence), with the third belonging to the affective register (mathematics anxiety).

It is also through the sense of competence that stereotypes (preconceived images generally shared at the socio-cultural level) – and especially gender stereotypes suggesting that mathematics is inherently a male domain – can affect students' success [31]. Even when controlling for students' prior grades in analyses (which themselves impact stereotypes), the presence of stereotypes predicts academic performance – as well as intentions to pursue careers in STEM fields – with the main mediating variable being the sense of competence [32]. While these authors obtain relatively similar modeling between girls and boys, the coefficients are nevertheless slightly more pronounced for girls. This difference is also found in a very different context (Singapore rather than Quebec), where the influence of the stereotype on the sense of competence is clearly unfavorable to girls [33]. The process by which stereotypes exert influence is highlighted in the model tested by Brodish *et al*. [34]. In mathematics, stereotype threat leads students to adopt performance-avoidance goals, which in turn cause marked concern about their own performance.

On the affective register, the more or less conscious – and relatively stable over time – feelings that students may experience in the context of learning mathematics can be distinguished from more fluctuating local affective states [35,36], which can sometimes be considered emotions strictly speaking. While the former are largely independent of specific situations encountered, the latter are clearly linked to the nature of the learning activities encountered. In terms of published research results, it is mainly broader measures that have been used. For example, the link between mathematics anxiety and success in this discipline has been highlighted repeatedly [30]. While Devine *et al*. [37] also reported moderate correlations between these variables, when they control for students' overall anxiety in evaluation situations, the link remains moderate for girls while it decreases very significantly for boys. Without making a particular distinction by gender, Bai [38] also noted a correlation of similar magnitude when testing the predictive validity of his questionnaire on students' performance. The very recent meta-analysis by Barroso *et al*. [39], aggregating 747 effect sizes from numerous publications, confirms this moderate link, which appears from the early years of schooling, increases somewhat in adolescence and then weakens somewhat in post-secondary grades.

Several plausible (and likely complementary) explanations help understand the impact of anxiety on student performance. Firstly, several studies note that negative affects induce thoughts that interfere with the learning process [40]. More specifically, students' attention, as well as their working memory capacities, are disrupted by the presence of negative emotions and especially by the intrusive rumination they can generate [41,42]. This is also the hypothesis supported in the Choking under Pressure theory [43] and the Processing Efficiency Theory [44], which suggest that the cognitive process useful for task resolution will be more or less strongly impacted by the affects felt, respectively stress, although there is – in cases of anxiety or stress – an increase in effort on the task to be performed. In other words, the most anxious students prove to be less fluent in solving mathematical tasks compared to their peers who solve problems correctly and quickly, using minimal cognitive resources, especially when it comes to the most complex exercises [45].

But reasons can also stem from the close links between affects and the cognitive dimensions of attitudes [19], especially the sense of competence. This variable indeed has the strongest correlation with anxiety ($r = -0.64$) in Lee and Stankov's meta-analysis [30]. The data from the international TIMMS survey allow for a parallel observation (with positive correlations) regarding positive affects experienced by students [46], whether it concerns mathematics or science. Indeed, both positive and negative affects are able to predict a student's sense of competence [47], knowing that the causal chain exhibits a certain circularity. While emotions, on the one hand, condition the student in their expectations and beliefs, the Control-value theory of achievement emotions [25] demonstrates how the student's sense of mastery and the value attributed to school and the learning activities offered can generate specific emotions, which in turn have repercussions on motivation and perceived success [48]. In their attempt to highlight the reciprocal relations between the two concepts through repeated measures, Ahmed *et al*. [49] concluded that the sense of competence affects anxiety more than the reverse.

Finally, examining the links between behavioral registry and student success brings a very clear and well-documented finding. Indeed, various measures of motivation (respectively investment, effort, or engagement according to the terminology and measures used in research) appear strongly correlated with students' outcomes [50,51]. Thus, the more students are willing to invest effort in their learning, the higher their results.

Two limitations need to be addressed regarding the consideration of the numerous results available in scientific publications, only a few of which have been reported above. The first concern, like the circularity discussed between affects and the sense of competence, is the actual causality of attitudes on student performance, which is difficult to demonstrate [52]. As Ma and Kishor [27] noted in their meta-analysis, only 4% of studies are conducted with a methodology that allows for determining causality, with the rest remaining at the level of correlational research designs. Indeed, the numerous structural equation models validated in studies are mostly based on data collected at a single point in time, thus not allowing us to conclude a specific causal direction. This is why the authors suggest the presence of reciprocal influences or only speak of the ability of attitude measures to predict student performance (assumed to be the dependent variable in regression models).

However, a few studies propose a longitudinal approach, thereby providing additional evidence regarding the direction of causality. This is for example the main objective of Ma and Xu's study [53], which concludes, based on the follow-up of numerous classes over six years, that students' success on a mathematics test (from the previous year) predominates in explaining attitudes (for the current year) rather than the reverse; a result replicated several times, year after year. However, beyond the desire to quantify the predominance of one causal direction over the other in these studies with at least two measurement points, it should be noted that reciprocal influences seem to be systematically present [54].

The second limitation concerns publication bias, which implies that less conclusive or non-significant results obtained by research teams generally do not get published in scientific journals (unpublished research or published in grey literature). While it is difficult to quantify such bias, the meta-analysis by Barroso *et al*. [39] – focusing on the links between anxiety and mathematics achievement – highlights, for example, that while the (negative) correlations are present in all types of research, the coefficients are nonetheless lower in the few unpublished studies (but which nevertheless could be retrieved). This implies a disproportionate visibility of some results compared to others.

1.3. Gender differences in attitudes

Although gender is not the main focus of research on attitudes, even in the field of mathematics, it is rare for publications to ignore this variable. We deliberately use the term "gender" in our discourse, even though the subjects of our research were questioned about their biological characteristic (sex). Indeed, gender is a cultural construction [55] that refers to social roles that influence individuals' expectations and behaviors. In this sense, the differences generally observed in attitudes cannot be interpreted purely by biological causes and indeed appeal to a socio-cultural functioning. Indeed, many studies integrate gender considerations to better understand the differential functioning of students, notably as an explanation for the very marked underrepresentation of girls who choose careers in Science, Technology, Engineering, and Mathematics (STEM) fields, despite similar skills in terms of their academic performance [56]. This present publication is no exception, as it seems interesting to question how girls and boys perceive their mathematical learning.

In the cognitive domain, differences are systematically highlighted in terms of the sense of competence, from the early primary grades [57,58], with even more contrasting results in adolescence [59]. Girls, who generally have a more critical view of their learning [60], then achieve lower scores than boys, who are quicker to be satisfied with their performance. The presence of stereotypes – related to students' sense of competence – is also predominantly found among boys [32,61]. However, these stereotypes are also present among some girls who justify their difficulties in this subject in this way [62]. The pattern is less clear for the utility attributed to learning mathematics during schooling, as some research highlights significantly higher scores for boys, especially in adolescence [63], while others indicate similar scores by gender [29].

The difference in anxiety (both for schoolwork and evaluations), which generally disadvantages girls [64], is exacerbated when it comes to mathematics in particular [37,59]. However, the affective domain is not limited to anxiety, and other affects also show a heterogeneous distribution by gender in the field of mathematics: for example, greater shame and despair among girls [65]; positive emotions – such as pleasure – are higher for boys [65,66].

In an apparently paradoxical manner, the behavioral domain presents an inverse pattern where girls mention a more significant investment than their male peers [62]. Indeed, despite a tendency to perceive the learning of mathematics more pessimistically than boys, both in terms of cognitive and affective domains, girls are more motivated and report dedicating more effort to it [59].

1.4. Attitudes in context

The differentiation of contexts allows for a better understanding, firstly, of the development of attitudes, but also subsequently, of the reasons for their maintenance and/or activation in certain situations. The family and school are the privileged places in which students' attitudes towards academic subjects develop, especially those concerning mathematics [18,67].

1.4.1. The role of family and school in attitude development

A child's first learning experiences typically occur within their family context. This is why the influence of parents is notable because parental attitudes directly influence those of their children [68]. Taking a closer look at the cognitive dimension of attitudes reveals that parental beliefs play a significant role. For instance, across three different samples (including one from Switzerland), Neuenschwander *et al*. [69] highlighted that parental expectations are significantly linked to their child's sense of competence, as well as their academic performance (in mathematics and the language of instruction).

The development of stereotypes within the family context is similarly linked to the gendered attribution models adopted by parents. Parents may believe that a girl's success in mathematics is due to her efforts, while a boy's success is attributed to his natural talent [70]. These beliefs affect children's perceptions of their own abilities and their performance in mathematical tasks. For example, if mothers adhere to the view of mathematics as an exclusively male domain, stereotype threat negatively influences their daughters' performance from the beginning of schooling [71]. Conversely, for girls whose mothers reject this view, no performance decline is observed. This influence of parental beliefs persists throughout schooling and affects not only children's perceptions but also their career trajectories [72].

Regarding the parental impact on affective aspects, children and adolescents' anxiety can be fueled by messages conveyed within the family (through transmitted stereotypes) as well as by an insecure attachment style [73]. In cases of anxiety, parental support helps children cope better with the situation, particularly through the development of optimistic perspectives and encouragement. It is also noteworthy that parents' own anxiety about mathematics is strongly correlated with that of their children, even in adolescence [74]. This relationship is even more pronounced in same-sex parent-child dyads, with a particularly strong effect on girls whose mothers have high mathematics anxiety [75]. Additionally, maternal attitudes impact children's motivation to learn mathematics and science [50,76]. Consequently, the behavioral dimension is also influenced by the family context, extending to the child's academic performance [77].

However, upon entering school, students are immersed in another context that also has repercussions on their attitudes toward learning: the classroom. Indeed, teachers' didactic choices (e.g., how content is presented, activities offered to students, methods, and evaluation criteria) impact students' perceptions, particularly on the development or reinforcement of their attitudes [78-80]. Specifically, classroom feedback strongly influences students' sense of competence through the internal discourses they create [81]. Moreover, it should be noted that parents are not the only ones who adopt stereotypical models, as many teachers also adhere to them [82]. In a study conducted with students at the end of primary school in Switzerland, Keller [83] demonstrated that teacher stereotypes directly affect those of students within their classes. Furthermore, this study highlights that the grade level (as well as the level of difficulty and demand in mathematical content) reinforces the presence of stereotypes. Teacher anxiety also influences the development of stereotypes in girls and, ultimately, their mathematics performance [84].

In terms of impact on the student's affective functioning, it is noteworthy that it is primarily the teacher's enthusiasm for teaching (not enthusiasm for the discipline itself) that has an impact on students' perceptions [85]. This emotional transmission of the joy of teaching to the joy of learning mathematics – understandable through the permanence of interactions in the classroom – can be directly observable through the teacher's behaviors [86] and could be, according to these authors, an interesting strategy to implement to improve student attitudes. When considering negative affects, affect contagion is found in some research concerning secondary schooling, but with limitations concerning the predominance of female teachers in these grades and the fact that disciplinary training in mathematics (one among many others in primary education) is not always adequate [87]. However, the development of anxiety – the most studied affect in the context of mathematics learning – can arise from teaching practices, especially from how the teacher develops mastery and performance goals within the classroom [88].

Although it has not been the subject of extensive research, the influence of peers within the classroom [50,89] and messages disseminated through media [33] can play a significant role in attitude development, particularly in gendered stereotypes, as students evolve in a socio-cultural context where many influences are present [90].

1.4.2. Attitudes in different contexts

Mathematics is not only a subject to master throughout schooling; they are also a tool used in professional contexts as well as in everyday life. Hart and Ganley [91] highlighted, in the general population, low to moderate anxiety, but still very high for 5% of the surveyed subjects. Unsurprisingly, they also observe lower anxiety among men and among individuals who have opted for a STEM career (both variables being strongly linked). Despite this, it is not always possible to avoid situations where mathematical reasoning is necessary (e.g., calculating a discount when making a purchase or subtracting the weight of a container in cooking).

In demonstrating differential functioning across contexts, various research studies have examined how certain children engaged in street vending transfer their skills (particularly mental arithmetic operations of addition, multiplication, and subtraction) to the more formal context of the classroom. Carraher *et al*. [92] found that while calculations performed in the street during coconut sales were correct in almost all situations encountered (98% of cases), these same adolescents had much more difficulty solving similarly challenging calculations in the school context (37% success rate); even when the problems were perfectly identical (74% success rate). Thus, the context – and notably its highly formal and perhaps "decontextualized" nature for the subjects in question – impacts performance, considering that the strategies used by subjects may differ depending on the context [93].

Having developed measurement instruments for motivation regarding specific situations encountered throughout learning (as opposed to measures concerning the motivation for mathematics and those at an even higher level that focus on general academic motivation), Boekaerts [94] tested different models that, depending on the context, better understand the links between attractiveness and task value, sense of competence, intention to engage, and affects. Their results confirm that while some links are stable regardless of the context, others can be clearly differentiated (especially in a homework situation). Therefore, students are sensitive to the specific contexts in which they learn, and the emotions experienced during mathematics lessons vary depending on the situations encountered and how students approach them [95].

Contextual variation can also be based on the didactic strategies used by the teacher. This is what Mason and Scrivani [80] specifically tested by proposing a three-month intervention aimed at introducing an innovative (rather than traditional) character in mathematics teaching. The impact of the approach (developing a classroom culture where students feel responsible for their understanding, encouraging a socio-constructivist approach in activities, and valuing divergent thinking) highlights a benefit on students' attitudes and beliefs, while simultaneously (and probably relatedly) improving their problem-solving skills. Although the intervention was not conducted by the regular teacher, students reacted differently in this particular context since their beliefs about mathematics (e.g., its utility) and their relationship to mathematics (e.g., working harder will impact their skills) are different.

Even more discreetly, contextual variation can be present through the voluntary activation of stereotypes by placing students in a situation where prior "gendered" labeling will impact attitudes and performance. This is the method used by Tomasetto *et al*. [71] by first asking students to listen to a story and draw a picture of it. Subjects are randomly assigned to two situations, one with the story of a girl with stereotypical characteristics, and the other of a fairyland with mushroom-shaped houses. Then, all students had to take a mathematics test adapted to their age. The results of this research indicate that stereotype activation clearly disrupts girls' performance, even after controlling for their previous results. Moreover, this performance decline directly contributes to reinforcing the stereotype since it then confirms expectations. This activation of stereotypes (including ethnic stereotypes present in mathematics) also affects adolescents. Ambady *et al*. [96], for example, highlight that such activation can have a protective effect in the advantaged group by the stereotype, particularly through certain success-related beliefs.

A somewhat indirect way to propose a different contextualization of the task specifically involves modifying its presentation. Indeed, such a stratagem allows observing the student facing the same task (or a similar task in substance) in a different guise. Morin-Messabel and Ferrière [97] tested the success of the same tasks (riddles of varying difficulty involving numbers) in "mathematics," "French," or "game" settings, i.e., without evaluation-related pressure. The researchers confirm their hypotheses, including that of different successes depending on the contexts, also interacting with students' gender, without there being generally a difference in performance between girls and boys. Furthermore, students report feeling more bored when solving these riddles in French than in the other two contexts. This felt boredom – which is a negative affect – is measured after the activity through a self-reported questionnaire; it is possible that students unconsciously moderate their discourse based on their supposed performance [97].

Still, in the field of mathematics, another study conducted by Huguet *et al*. [98] also highlighted different achievement levels of students by varying the evaluation context. The students (only boys) – divided into two groups based on their previous results (high-achieving vs. low-achieving in mathematics) – had to memorize and then reproduce the complex figure of Rey-Osterrieth, a task frequently used in the psychological assessment of students and possessing very precise coding criteria. This activity was presented to them as a measure of their geometry skills, respectively drawing skills. If the results of the two groups of students are similar in the second context (drawing), with an average score, those who found themselves in the "geometry" condition show significantly different achievement levels according to their academic level. High-achieving students were more successful while lower-achieving ones obtained markedly lower scores.

We drew inspiration from these studies (particularly the last one) to better understand how attitudes help to differentially explain success in a mathematical task in two different contexts. Indeed, if research highlights that students are sensitive to the presentation of the task or, more generally, to the context in which it takes place, we can expect that attitudes towards the discipline also play a different role depending on the particular activation generated by the context. More concretely, we seek to predict the outcome of a mathematical problem proposed in two different contexts (mathematics class vs. French class) based on the attitudes that students demonstrate towards the respective disciplines. Our inquiry also aims to differentiate the impact of attitudes according to gender.

2. Methodology

2.1. Sample

The convenience sample consists of 94 students with an average age of 14.1 years (SD = 0.5). The gender distribution is representative of the population: girls (*n* = 48) have an average age of 14.0 years (SD = 0.5) and boys (*n* = 46) have an average age of 14.2 years (SD = 0.5). These students come from four classes of 10th grade HarmoS (penultimate year of compulsory schooling) of the "general" type (corresponding to an average level of requirement) in a school in French-speaking Switzerland.

2.2. Materials and procedure

Prior to the assessments, proportion calculations (also known as the "rule of three") were pre-tested in a class not participating in the present study to ensure the optimal difficulty level of the exercise. It should be noted that this type of problem was addressed in the previous year's curriculum but has not been explicitly recalled recently.

Two equivalent proportion calculations were therefore proposed to the students in two different contexts (math class and French class), three weeks apart and counterbalanced to avoid a test-retest effect: two classes first had the problem in the math context, then in the French context, and vice versa for the other two classes. These two exercises were inserted as part of formative assessments (not taken into account for the school report card) and submitted, at the agreed time, by their respective discipline teachers without specific consultation. They were presented to the students as exercise sheets for which feedback would be provided later.

Regarding the mathematics assessment, the worksheet consists of six exercises (calculating the perimeter and area of a rectangle, sorting decimal values in ascending order, unit conversion, etc.), among which is the following proportion calculation:

"A bottle of soda contains 924 grams of sugar. Knowing that 2.5dl of this soda contains 154 grams of sugar, how many deciliters of soda does the bottle contain?"

The French evaluation sheet, on the other hand, proposes five exercises related to the dictionary (searching for synonyms, alphabetical order of words, estimating the number of words in the dictionary, etc.), including a proportion calculation to be performed:

"In the French dictionary, 960 words start with the letter U. Knowing that 2.5 pages contain about 160 words, how many pages contain words starting with the letter U approximately?"

During a subsequent math class after the assessments in both contexts (to avoid bias), the students also completed a questionnaire to assess their socio-affective attitudes toward learning mathematics (see **Section 2.3.**). Subsequently, they were informed of the research objectives and orally questioned about the setup. None of them indicated noticing the presence of very similar exercises in both classes.

2.3. Measures

While both sets of exercises received feedback from the students, we only retained for our research the results of the two proportion calculations, evaluated dichotomously (correct vs. incorrect), which then constituted two dependent variables (one per context). Since proportion calculation exercises concern mathematical skills, it seemed interesting to us to retrieve their current average math grade. Additionally, we administered a questionnaire evaluating socio-affective attitudes toward math [22]. This questionnaire measures seven components of attitudes across three registers, also incorporating a measure of gender stereotypes (see **Table 1**). Each of the 45 items is self-assessed by the student on a 6-point Likert scale ranging from 0 (Strongly Disagree) to 5 (Strongly Agree).

Table 1. Questionnaire of socio-affective attitudes in mathematics

Register	Dimension (and examples of items)	*n*	Cronbach's *α*	
			Baseline study	Current research
Cognitive	Utility: Being good at math gives a considerable advantage in finding a job.	5	0.80	0.77
	Competence: I am talented in math.	6	0.94	0.90
	Controllability: My understanding of math depends on the effort I put in.	5	0.74	0.68
	Stereotype (masculinity): A girl must work harder than a boy to achieve the same results in math.	5	0.86	0.82
Affective	Positive affects: I look forward to math class.	6	0.93	0.94
	Negative affects: I easily get tense during math class.	6	0.88	0.82
	Affective regulation: I am able to manage my emotions during math class.	6	0.79	0.72
Behavioral	Investment: I engage in activities and exercises during math class.	6	0.83	0.81

We observe that the internal consistencies (measured using Cronbach's alpha coefficient) of the different dimensions are slightly lower than in the questionnaire validation study [22]. This is probably due to the fact that the subjects were slightly older (post-compulsory education students) than those in the present sample. However, the coefficients obtained remain satisfactory to very good.

3. Presentation and discussion of results

We present in **Table 2** below the means, standard deviations, and the skewness and kurtosis indices of the various quantitative measures conducted with our sample.

Table 2. Descriptive statistics of quantitative variables

Dimension	Mean	SD	Skewness	Kurtosis
Utility	3.57	1.03	-0.82	0.38
Competence	2.60	0.93	-0.28	-0.78
Controllability	3.50	0.96	-0.46	-0.35
Stereotype (masculinity)	1.02	1.15	1.52	2.30
Positive affects	2.45	1.47	0.01	-0.99
Negative affects	1.18	1.06	1.07	0.97
Affective regulation	3.48	0.90	-0.74	0.67
Investment	3.73	0.87	-0.90	1.23
Math grade average	4.63	0.63	-0.79	0.78

The examination of the coefficients reveals that the measurement of stereotypes tends towards a floor effect. If a low average in this dimension means that students generally do not share the idea that mathematics is a masculine discipline – which is reassuring in itself – it nonetheless remains that some scores approach the maximum score on the scale. This results in a relatively pronounced dispersion, allowing us to consider parametric statistics. Similarly, the distribution of negative affects also shows a stronger positive skewness, while still maintaining a kurtosis closer to normal.

3.1. Gender differences in attitudes

Before examining the links between attitudes and students' performance on the two target exercises of our research, it seems necessary – in light of our questions – to compare the attitudes of students according to gender (see **Figure 1**). At the cognitive level, boys perceive more utility in learning mathematics than girls ($t_{(92)} = 3.02$; $P < 0.01$), and, not surprisingly, consider themselves more competent ($t_{(92)} = 2.70$; $P < 0.01$). Interestingly, it is worth noting that the average grade in mathematics at the time of the assessment is entirely similar ($M_{girls} = 4.63$; $M_{boys} = 4.64$). Consequently, this result aligns well with the findings of other previous research that highlight that, at equal performance, boys feel more competent than girls.

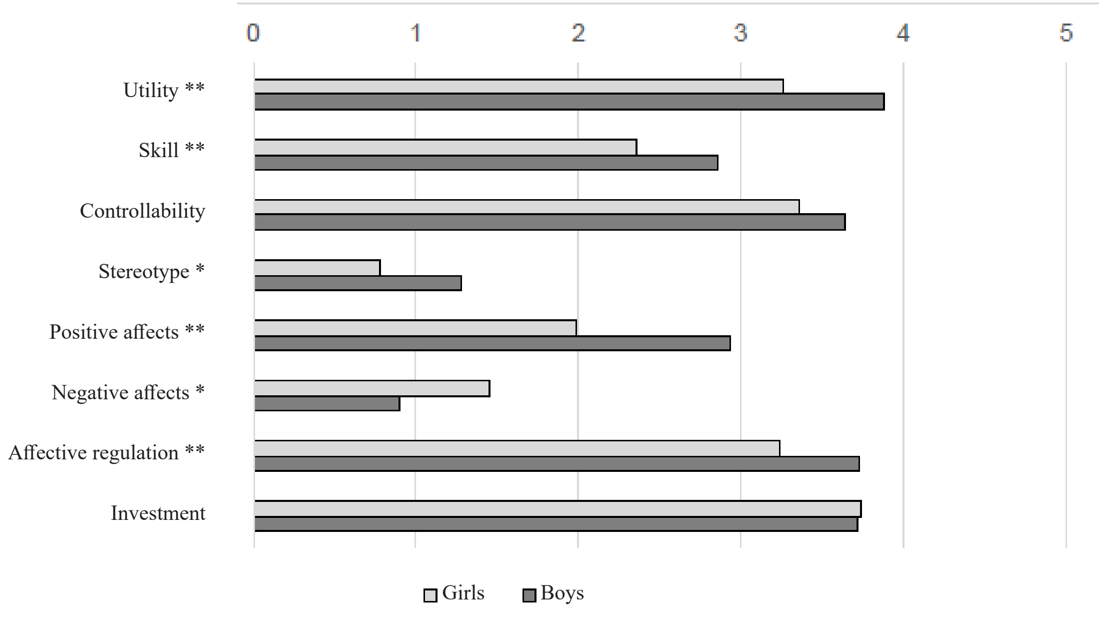

Figure 1. Gender differences in the eight dimensions of attitudes. Significant difference at *$P < 0.05$ and **$P < 0.01$

If, at the level of controllability – meaning the tendency to believe that one's behavior and efforts have a real impact on performance – the difference is not significant, the one concerning gender stereotype is again more pronounced ($t_{(92)} = 2.12$; $P < 0.05$). As expected, students thus value the stereotype that is favorable to their group, whether it is gender as here or other characteristics [99]. It is also necessary to mention that apart from the very asymmetric distribution of this dimension (tendency toward a floor effect), its dispersion is much stronger in the group of boys (SD = 1.27) than in that of girls (SD = 0.78), with scores even approaching the maximum value of the scale for some of them. As we have shown with another sample [62], these are boys with good results in mathematics who explain their ease in this discipline by the fact that they are male.

The pattern relative to dimensions of the affective registry is also well differentiated by gender since our data undeniably align with well-established results [62]. In particular, girls report feeling significantly fewer positive affects compared to boys (this is where the most marked difference lies; $t_{(92)} = 3.29$; $P < 0.01$), as well as more negative affects ($t_{(92)} = -2.58$; $P < 0.01$) when learning mathematics. Such results are found by other authors, notably Frenzel *et al.* [65], who also distinguish between different types of positive affects (pleasure and pride) and negative affects (anxiety, despair, and shame). This has the corollary that girls also feel they are generally less successful in coping with their stress and anxiety since affective regulation is a dimension for which the difference is also significant ($t_{(92)} = 2.66$; $P < 0.05$).

The only more surprising result concerns investment since both groups have similar scores ($t_{(92)} = -0.12$; ns) whereas we could expect a difference in favor of girls based on the gap highlighted with the same questionnaire among a very similar sample [62]. Therefore, it seems, since the dimension is not subject to episodic fluctuations (it indeed has good temporal stability: $r_{tt} = 0.85$ [22]), that the fact that our sample only includes students in 10th grade in classes with an intermediate level of demand (type “general”) could explain this result. Indeed, if a gradual decline in motivation is observed throughout secondary education, students in this intermediate track show a stronger deterioration in their motivation in 10th grade, before it strengthens in 11th grade when training prospects become clearer at the end of compulsory schooling [64]. It is likely that this particular evolution, linked to some anxiety about the future after leaving school, affects girls more, whose motivation scores for learning then align with those of boys.

3.2. Attitudes and mathematics academic achievement

The second set of results concerns the relationships between mathematics performance (as measured by school grades) and the attitudes that students develop towards this discipline. The current school grades of students in this subject range from 2.50 to 5.50 (M = 4.63; SD = 0.63). Similar to the assessments conducted within the school context, the distribution exhibits a normal curve but with a moderate negative skew. However, the parametric tests we employ are robust enough to tolerate this type of distribution.

Table 2 presents the correlations that have been calculated for all students, respectively separately by gender. Due to the multicollinearity of the different dimensions of attitudes, we have chosen to highlight the relationships through correlations (rather than regressions), conducting them separately for girls and boys to highlight any potential moderating effect of gender.

Table 2. Correlations between current mathematics grade and soci0-affective attitudes

Dimension	Total (*n* = 94)	Girls (*n* = 48)	Boys (*n* = 46)
Utility	0.27*	0.15	0.44**
Competence	0.68**	0.64**	0.76**
Controllability	0.38**	0.38**	0.38*
Stereotype	-0.23*	-0.43**	-0.09
Positive affects	0.44**	0.37*	0.54**
Negative affects	-0.39**	-0.44**	-0.34*
Affective regulation	0.36**	0.31*	0.45**
Investment	0.27**	0.20	0.34*

*$P < 0.05$; ** $P < 0.01$

The dimension most strongly correlated with the student’s grade is their sense of competence. As we discussed in the introduction of this article, there are undoubtedly mutual influences. Results shape the sense of competence, as it is largely based on the grades the student receives, allowing them to assess their competencies relative to their peers; the sense of competence has indirect repercussions on results, particularly through increased motivation for learning in which the student feels skilled.

For most dimensions, the pattern remains relatively similar by gender. However, the two dimensions show more disparate correlations between the two groups (highlighted in bold in the table). Although not significant

($t_{(88)}$ = 1.47; ns), the difference concerning perceived utility is nevertheless interesting to note. Boys with good grades in mathematics feel that this discipline will be particularly useful for their education or future profession, while this link is not really present among girls. The fact that boys more easily envision a professional activity related to STEM fields [56] undoubtedly explains the very direct interest that a good mastery of mathematics can have for them. The other difference between girls and boys, significant this time ($t_{(88)}$ = 1.77; $P < 0.05$), concerns stereotypes. While the correlation is null among boys, it is marked among girls, as is the correlation regarding negative affects. These two results can indeed be discussed together since stereotype threat has an impact on the anxiety felt by students. Indeed, this threat involves a chain of physiological and cognitive reactions (negative thoughts) that influence affective experience and, consequently, the resources available in the task [100]. Osborne [101] was able to highlight the presence of stereotype-related anxiety, which plays – at least in part – a mediating role in explaining mathematics results. Furthermore, other works [102] have shown that adopting a lower performance reputation among students, caused by the stereotype, generates a disruptive mental load that ultimately explains the difference in task capacity.

3.3. Impact of attitudes across context

The third and final set of results presented below constitutes the core of our research. Here, we aim to examine which dimensions of attitudes are likely to have a differential impact on students' results (specifically, a proportion calculation) in two different contexts: mathematics class and French class. To achieve this, after correcting the exercises completed by the students (based on "passed" or "failed" criteria), we conducted logistic regressions to examine predictors of a dichotomous dependent variable. These regressions were parameterized using the forward stepwise method to retain only significant predictors. Due to the strong multicollinearity of attitude dimensions, it was necessary to optimize the analysis to highlight the predominant predictor(s).

In the context of the mathematics class (see **Figure 2**), we first observed a slightly better success rate for girls (77% compared to 65% for boys). Although this difference is not significant, their sigmoid curve is indeed consistently above that of boys. Next, the analysis identified only one significant predictor: negative affects. If the probability of success is very high (93%) for students who generally do not experience stress or anxiety during math class, it drops dramatically to 15% for those who score maximum (5 on the scale used in the questionnaire) in this dimension. The coefficients of this analysis ($R^2_{\text{Cox \& Snell}}$ = 0.14; $R^2_{\text{Nagelkerke}}$ = 0.16) are not very high. However, the chi-square is not significant ($\chi^2_{(8)\ \text{Hosmer \& Lemeshow}}$ = 10.06; ns), indicating a good fit of the data to the model.

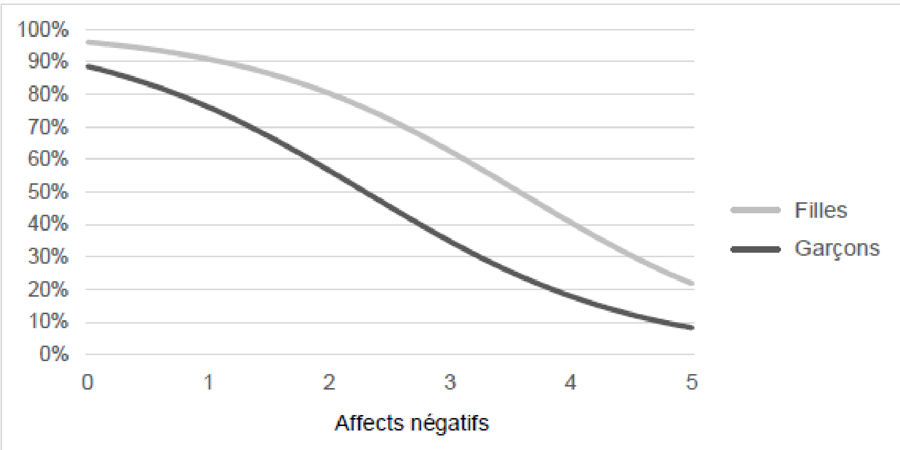

Figure 2. Probability of success by gender in proportion calculation in mathematics context

An identical logistic regression analysis – conducted on data collected from the same students, but in a French context this time – yields a different result (see **Figure 3**). While no gender difference appears here, it is positive affects that best predict the probability of students' success, with coefficients in the same order of magnitude: $R^2_{Cox\ \&\ Snell} = 0.15$; $R^2_{Nagelkerte} = 0.17$; $\chi^2_{(8)\ Hosmer\ \&\ Lemeshow} = 8.53$; ns. Although the slope of the sigmoid is slightly lower, the difference in the probability of success for students who feel no pleasure in learning mathematics (37%) versus those who have a lot of pleasure in this discipline (83%) is still significant.

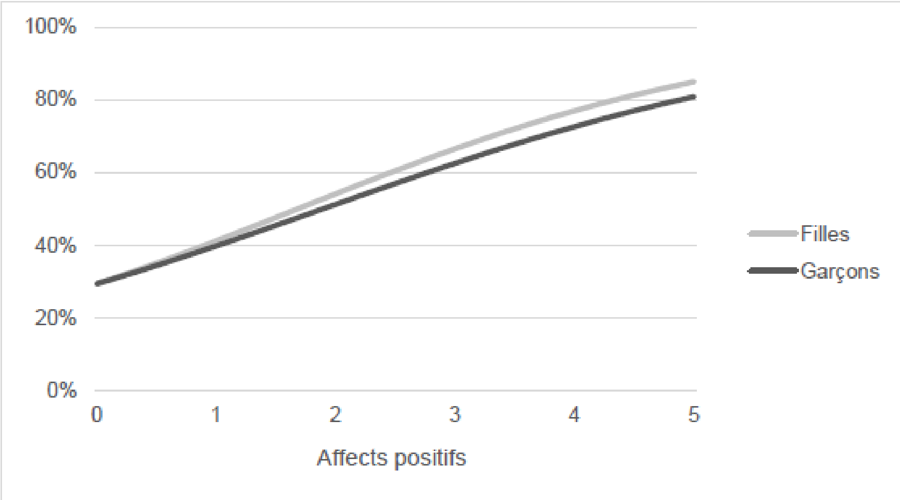

Figure 3. Probability of success by gender in the proportion calculation in a French context

Since we balanced the methodological plan so that some students first encounter the mathematics context and then the French context, and vice versa for the other part, it should be noted here that we did not find any particular difference according to the order of task presentation (a variable taken into account in the analyses presented below). There does not seem to be a learning effect that would lead students to perform better during the second assessment.

In both contexts, it is therefore emotions that best predict a student's success in a given calculation task. It should be noted in this regard that this result can be explained by the fact that, in the domain of attitudes, affective aspects (compared to cognitive aspects) develop rapidly and remain more stable over time [103]. We can also assume that these aspects are less fluctuating depending on the particular task performed by the student and therefore remain in the background throughout the lesson (whether it's mathematics or French). In other words, when the student starts the mathematics class, they are in a certain affective disposition (or mood) that changes only slightly depending on the activities proposed, their difficulty, or other characteristics. This affective predisposition is thus "triggered" or "activated" and will subsequently play a role in all behaviors (including learning) of the student.

This process is similar to that highlighted in various research studies that rely on stereotype threat theory. Using various strategies, researchers aim to activate the stereotype to generate emotions that will either improve or, more often, disrupt performance. In the work of Smeding *et al.* [104], students (in 8th grade) are subjected to a verbal test and a math test in succession, but in reverse order for part of the sample. In this way, the device allows girls who are first questioned in mathematics to stimulate stereotype threat, which will then have a visible impact on performance in the verbal test. It is also possible to differentially activate stereotype threats related to gender and ethnic origin. This is what Shih *et al.* [105] did with a sample (tertiary level) of American female students of Asian descent. When their ethnic identity is activated, they perform better on a math test, while their performance is poorer when their sexual identity is activated.

However, this is not an activation of stereotype threat (even disguised) because we did not seek to propagate a stereotype about a particular group and emphasize the risk that individual performance would be judged based on this stereotype [106]. We have proof of this because girls' success is higher in the context of mathematics class, whereas activation of the stereotype would have negatively affected their performance (because the stereotype is unfavorable to them). As indeed mentioned by Huguet *et al*. [98] – regarding their research from which we drew inspiration for this present study – the two contexts in which the task is performed will activate their performance history and, more broadly, their past social experiences. We also add that this reactivated history undoubtedly concerns the moods generally present in one or another particular context. Unlike the device set up by Huguet *et al*. [98] which compares the success of the same task in a drawing context or a mathematics-geometry context, here we have two disciplines considered academically important. Thus, the fact that the results are not identical depending on the context cannot be explained by the difference in the academic valence of the two disciplines concerned since both French and mathematics are considered at the top of the hierarchy of school subjects. However, it is not possible to exclude the hypothesis that some students were less invested in this calculation exercise in the context of the French class due to the mismatch between the type of task and the content usually covered during this class.

The differential framing of the task causes a very similar phenomenon. By proposing the same exercise in a French context, in a mathematics context, or as a fun activity, it is possible to indirectly create pressure that will lead students to mobilize different cognitive strategies [97]. This pressure thus creates a mental burden that is also linked to the affective state since its physiological manifestations can be observed through heart rate variability [102].

Starting from the hypothesis that by proposing the task in two different contexts, we have thus provoked a different activation of attitudes (especially affective ones), we can then separately explain the phenomenon in each of the two classes. In the context of mathematics, students who are generally anxious about activities found themselves more challenged to succeed in the requested calculation. Indeed, numerous studies have shown that anxiety leads to a decrease in performance. Worry diverts attention from the task to be accomplished [34] while creating a vicious circle since failing the task in turn increases anxiety and related rumination. In addition, emotional regulation strategies - which are varied - are not always necessarily adaptive. Indeed, students sometimes develop strategies to reduce their anxiety which distances them from learning (e.g., daydreaming about other things to avoid being overwhelmed by emotions). However, even when they are task-focused (e.g., having an internal dialogue with positive self-verbalizations to motivate oneself), these strategies often require some cognitive resources that are then no longer directly allocated to solving the exercise.

In the context of the French class, however, the negative emotions that students may generally feel about learning mathematics are not activated during the class, in the background. Thus, when they are faced with a calculation to be done, anxiety plays a much more secondary role than pleasure, which then becomes the predominant explanatory factor. Indeed, positive emotions lead the student to increase concentration on the task which provides them with pleasure [40]. The link between positive affects and emotions is well documented [19,107], and the pleasure felt by the student seems to have a greater impact on the student's motivation than the inhibition produced by anxiety [47]. This is also the reason why a playful framing of the task leads, on the one hand, to more pleasure for the student as well as a lightening of evaluative pressure which will favor the performance of the students [97].

4. Conclusion

The attitudes a student develops towards academic disciplines have repercussions on how they approach learning and, ultimately, on their academic performance. Similar to many other studies mentioned above, our research conducted in the field of mathematics first highlighted the important links between various dimensions of attitudes and students' performances, measured by their average school grades in this discipline. While the dimensions of the three registers (cognitive, affective, and behavioral) show moderate to strong correlations with students' grades, we are unable to determine any causality. We can only suggest a reciprocal influence while noting again that the various dimensions of attitudes themselves are often interdependent and fluctuate together.

Regarding gender differences in attitudes, our research also confirms the conclusions of previous studies addressing this question, namely that concerning the learning of mathematics, girls' attitudes are clearly more detrimental. Indeed, except for adherence to stereotypes (and considering that investment is almost identical by gender), girls perceive less utility in learning mathematics, feel less competent, and report much less enjoyment but more anxiety, while also claiming to regulate their emotions less well. Despite this, they achieve a mathematics average (average grade at the time of assessment) identical to that of boys and also have a higher success rate in the exercise requested. Therefore - and considering the impact of attitudes on results - it would be interesting to measure the potential gain in terms of results if girls developed attitudes as positively as their male peers.

Finally, our study aimed to examine to what extent attitudes differentially explain success in two different contexts, but of equivalent academic valence (mathematics and French being considered as main subjects in the Swiss school system). It thus fits into the stream of research aimed at activating certain specific attitudes and examining their repercussions on students' feelings, behaviors, or performances. While the framework of our experimentation is obviously not at all applicable to teaching this discipline (it is not conceivable to address mathematical content during other classes), this approach has nevertheless shown a contextualized functioning of students with different emotions that predominantly explain success. Thus, in the context of mathematics class, it is the anxiety generally felt by the student in this context that disrupts problem-solving. Conversely, during the French class, it is the positive emotions that facilitate success in a very similar calculation.

Our work presents various limitations that do not only concern the small size of the sample. First, the significant multicollinearity between predictors led us to perform regression analyses with an ascending method. This allowed us to highlight the predominant predictors to the detriment of other predictors whose weight is weaker, but whose presence undoubtedly plays a role (even indirectly). However, this obstacle is inherent in such measures since it is not possible to keep certain dimensions of attitudes stable while strongly fluctuating others. Cognitive, affective, and behavioral aspects (especially motivation) are closely related to each other, and the "all else being equal" approaches cannot then be envisaged. Then, our measure of attitudes assesses how students perceive learning in mathematics in general. It would be relevant to add targeted measures when performing exercises (such as the value attributed to the task). Similarly, a distinction concerning types of regulation (adaptive or non-adaptive) would undoubtedly refine our understanding of how students function in different contexts.

Despite this, our results underline the importance of working with students on their emotional feelings, which provides a different perspective on interventions generally proposed in classrooms. Indeed, many pedagogical approaches are currently being implemented to address stereotype threat [61] and therefore mainly focus on cognitive aspects. Plante *et al*. [32] indicated an interest in considering the value of the task perceived by students while developing a stronger sense of competence. Moreover, as research programs gradually consider emotion, motivation, and cognition as equal components of the social learning process [108,109], interventions increasingly integrate strategies aimed at better-regulating emotions [110]. It seems necessary to go even further in this direction – in connection with the development of positive psychology – and to consider interventions that focus on the development and maintenance of positive affects during learning.

Disclosure statement

The author declares no conflict of interest.

References

[1] Vallerand RJ, Thill EE, 1993, Introduction à la Psychologie de la Motivation. Éditions Études Vivantes.

[2] Stack KF, Dever BV, 2021, Predicting Eighth Grade Math Motivation Using School and National Context. School Psychology, 36(3): 181–189. https://doi.org/10.1037/spq0000431

[3] Albisetti ZI, 2021, Le Sentiment de Sécurité en Milieu Scolaire: Analyse des Dynamiques Sous-Jacentes Aux Comportements Apprenants des Élèves, thesis, Université de Fribourg.

[4] Šimunović M, Babarović T, 2020, The Role of Parents' Beliefs in Students' Motivation, Achievement, and Choices in the STEM Domain: A Review and Directions for Future Research. Social Psychology of Education, 23: 701–719. https://doi.org/10.1007/s11218-020-09555-1

[5] Weiner B, 1985, An Attributional Theory of Achievement Motivation and Emotion. Psychological Review, 92(4): 548–573. https://doi.org/10.1037/0033-295x.92.4.548

[6] Bong M, Clark RE, 1999, Comparison Between Self-Concept and Self-Efficacy in Academic Motivation Research. Educational Psychologist, 34(3): 139–153. https://doi.org/10.1207/s15326985ep3403_1

[7] Nolen SD, 2019, Conceptualizing Goals in Motivation and Engagement, in The Cambridge Handbook of Motivation and Learning. Cambridge University Press, 547–565. https://doi.org/10.1017/9781316823279.024

[8] Waxman HC, 1991, Investigating Classroom and School Learning Environments: A Review of Recent Research and Developments in the Field. Journal of Classroom Interaction, 26(2): 1–4. https://psycnet.apa.org/record/1992-37110-001

[9] Weinstein RS, 1983, Student Perceptions of Schooling. Elementary School Journal, 83(4): 287–312. https://doi.org/10.1086/461319

[10] Raynal F, Rieunier A, 2001, Pédagogie: Dictionnaire des Concepts Clés (3rd ed). ESF. https://doi.org/10.14375/np.9782710126508

[11] Ntamakiliro L, Monnard I, Gurtner J-L, 2000, Mesure de la Motivation Scolaire des Adolescents: Construction et Validation de Trois Échelles Complémentaires. Orientation Scolaire et Professionnelle, 29(4): 673–693. https://doi.org/10.4000/osp.5788

[12] Viau R, 1997, La Motivation en Contexte Scolaire. De Boeck & Larcier.

[13] Triandis HC, 1971, Attitude and Attitude Change. John Wiley & Sons.

[14] Scherer KR, 2005). What are Emotions? And How Can They Be Measured? Social Science Information, 44(4): 695–729. https://doi.org/10.1177/0539018405058216

[15] Rosenberg EL, 1998, Levels of Analysis and the Organization of Affect. Review of General Psychology, 2: 247–270. https://doi.org/10.1037/1089-2680.2.3.247

[16] Hopko DR, Mahadevan R, Bare RL, 2003, The Abbreviated Math Anxiety Scale (AMAS). Construction, Validity, and Reliability. Assessment, 10(2): 178–182. https://doi.org/10.1177/1073191103010002008

[17] Suinn RM, Edwards R, 1982, The Measurement of Mathematics Anxiety: The Mathematics Anxiety Rating Scale for Adolescents – MARS-A. Journal of Clinical Psychology, 38(3): 576–580. https://doi.org/10.1002/1097-

4679(198207)38:3<576::aid-jclp2270380317>3.0.co;2-v

[18] Aiken LR, 1972, Research on Attitudes Toward Mathematics. The Arithmetic Teacher, 19(3): 229–234. https://doi.org/10.2307/1169746

[19] Pekrun R, Goetz T, Frenzel AC, et al., 2011, Measuring Emotions in Students' Learning and Performance: The Achievement Emotions Questionnaire (AEQ). Contemporary Educational Psychology, 36(1): 36–48. https://doi.org/10.1016/j.cedpsych.2010.10.002

[20] Chamberlin SA, 2010, A Review of Instruments Created to Assess Affect in Mathematics. Journal of Mathematics Education, 3(1): 167–182.

[21] Aiken LR, 1974, Two Scales of Attitude Toward Mathematics. Journal for Research in Mathematics Education, 5(2): 67–71. https://doi.org/10.2307/748616

[22] Genoud PA, Guillod M, 2014, Développement et Validation d'un Questionnaire Évaluant les Attitudes Socio-Affectives en Maths. Recherches en Éducation, 20: 140–156. https://doi.org/10.4000/ree.8149

[23] Vezeau C, Chouinard R, Bouffard T, et al., 1998, Adaptation et Validation des Échelles de Fennema et Sherman sur les Attitudes en Mathématique des Élèves du Secondaire. Revue Canadienne des Sciences du Comportement, 30(2): 137–140. https://doi.org/10.1037/h0085804

[24] Chapman E, 2003, Development and Validation of a Brief Mathematics Attitude Scale for Primary-Aged Students. Journal of Educational Enquiry, 4(2): 63–73.

[25] 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

[26] Papanastasious C, 2000, Effect of Attitude and Belief on Mathematics Achievement. Studies in Educational Evaluation, 26: 27–42. https://doi.org/10.1016/S0191-491X(00)00004-3

[27] Ma X, Kishor N, 1997, Attitude Toward Self, Social Factors, and Achievement in Mathematics: A Meta-Analytic Review. Educational Psychology Review, 9(2): 89–120. https://doi.org/10.1023/A:1024785812050

[28] Peetsma T, Hascher T, van der Veen I, et al., 2005, Relations Between Adolescents' Self-Evaluations, Time Perspectives, Motivation for School and Their Achievement in Different Countries and at Different Ages. European Journal of Psychology of Education, 20(3): 209–225. https://doi.org/10.1007/bf03173553

[29] Chouinard R, Karsenti T, Roy N, 2007, Relations Among Competence Beliefs, Utility Value, Achievement Goals, and Effort in Mathematics. British Journal of Educational Psychology, 77(3): 501–517. https://doi.org/10.1348/000709906x133589

[30] Lee J, Stankov L, 2013, Higher-Order Structure of Noncognitive Constructs and Prediction of PISA 2003 Mathematics Achievement. Learning and Individual Differences, 26: 119–130. https://doi.org/10.1016/j.lindif.2013.05.004

[31] Cheryan S, 2012, Understanding the Paradox in Math-Related Fields: Why Do Some Gender Gaps Remain While Others Do Not? Sex Roles, 66(3–4): 184–190. https://doi.org/10.1007/s11199-011-0060-z

[32] Plante I, de la Sablonnière R, Aronson JM, et al., 2013, Gender Stereotype Endorsement and Achievement-Related Outcomes: The Role of Competence Beliefs and Task Values. Contemporary Educational Psychology, 38(3): 225–235. https://doi.org/10.1016/j.cedpsych.2013.03.004

[33] Cvencek D, Meltzoff AN, Kapur M, 2014, Cognitive Consistency and Math-Gender Stereotypes in Singaporean Children. Journal of Experimental Child Psychology, 117: 73–91. https://doi.org/10.1016/j.jecp.2013.07.018

[34] Brodish AB, Devine PG, 2009, The Role of Performance – Avoidance Goals and Worry in Mediating the Relationship Between Stereotype Threat and Performance. Journal of Experimental Social Psychology, 45(1): 180–185. https://doi.org/10.1016/j.jesp.2008.08.005

[35] Goldin GA, 2000, Affective Pathways and Representation in Mathematical Problem Solving. Mathematical Thinking and Learning, 2(3): 209–219. https://doi.org/10.1207/s15327833mtl0203_3

[36] Rouxel G, 2000, Cognitive-Affective Determinants of Performance in Mathematics and Verbal Domains. Gender differences. Learning and Individual Differences, 12: 287–310. https://doi.org/10.1016/s1041-6080(01)00041-3

[37] Devine A, Fawcett K, Szücs D, et al., 2012, Gender Differences in Mathematics Anxiety and the Relation to Mathematics Performance While Controlling for Test Anxiety. Behavioral and Brain Functions, 8(33): 1–9. https://doi.org/10.1186/1744-9081-8-33

[38] Bai H, 2011, Cross-Validating a Bidimensional Mathematics Anxiety Scale. Assessment, 18(1): 115–122. https://doi.org/10.1177/1073191110364312

[39] Barroso C, Ganley CM, McGraw AL, et al., 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

[40] Meinhardt J, Pekrun R, 2003, Attentional Resource Allocation to Emotional Events: An ERP Study. Cognition and Emotion, 17(3): 477–500. https://doi.org/10.1080/02699930244000039

[41] Whitmer AJ, Gotlib IH, 2013, An Attentional Scope Model of Rumination. Psychological Bulletin, 139(5): 1036–1061. https://doi.org/10.1037/a0030923

[42] Zan R, Brown L, Evans F, et al., 2006, Affect in Mathematics Education: An Introduction. Educational Studies in Mathematics, 63: 113–121. https://doi.org/10.1007/s10649-006-9028-2

[43] Beilock SL, Kulp CA, Holt LE, et al., 2004, More on the Fragility of Performance: Choking Under Pressure in Mathematical Problem Solving. Journal of Experimental Psychology: General, 133(4): 584–600. https://doi.org/10.1037/0096-3445.133.4.584

[44] Eysenck MW, Calvo MG, 1992, Anxiety and Performance: The Processing Efficiency Theory. Cognition and Emotion, 6(6): 409–434. https://doi.org/10.1080/02699939208409696

[45] Cates GL, Rhymer KN, 2003, Examining the Relationship Between Mathematics Anxiety and Mathematics Performance: An Instructional Hierarchy Perspective. Journal of Behavioral Education, 12: 23–34. https://doi.org/10.1023/A:1022318321416

[46] Marsh HW, Abduljabbar AS, Abu-Hilal MM, et al., 2013, Factorial, Convergent, and Discriminant Validity of TIMSS Math and Science Motivation Measures: A Comparison of Arab and Anglo-Saxon Countries. Journal of Educational Psychology, 105(1): 108–128. https://doi.org/10.1037/a0029907

[47] Genoud PA, Kappeler G, Gay P, 2020, Faut-il Former les Enseignants Afin Qu'ils Cherchent à Diminuer les Émotions Négatives de Leurs Élèves ou Qu'ils Leur Apprennent à Renforcer Leurs Émotions Positives? Recherches en Education, 41: 31–45. https://doi.org/10.4000/ree.519

[48] King RB, Gaerlan MJM, 2014, High Self-Control Predicts More Positive Emotions, Better Engagement, and Higher Achievement in School. European Journal of Psychology of Education, 29: 81–100. https://doi.org/10.1007/s10212-013-0188-z

[49] Ahmed W, Minnaert, A, Kuyper H, et al., 2012, Reciprocal Relationships Between Math Self-Concept and Math Anxiety. Learning and Individual Differences, 22(3): 385–389. https://doi.org/10.1016/j.lindif.2011.12.004

[50] Leaper C, Farkas T, Brown CS, 2012, Adolescent Girls' Experiences and Gender-Related Beliefs in Relation to Their Motivation in Math/Science and English. Journal of Youth and Adolescence, 41(3): 268–282. https://doi.org/10.1007/s10964-011-9693-z

[51] Xu J, 2018, Reciprocal Effects of Homework Self-Concept, Interest, Effort, and Math Achievement. Contemporary Educational Psychology, 55: 42–52. https://doi.org/10.1016/j.cedpsych.2018.09.002

[52] McLeod D, 1992, Research on Affect in Mathematics Education: A Reconceptualization, in Handbook of Research on Mathematics Learning and Teaching. Macmillan, 575–596.

[53] Ma X, Xu J, 2004, Determining the Causal Ordering Between Attitude Toward Mathematics and Achievement in Mathematics. American Journal of Education, 110(3): 256–280. https://doi.org/10.1086/383074

[54] Lee C, Kung H, 2018, Math Self-Concept and Mathematics Achievement: Examining Gender Variation and Reciprocal Relations Among Junior High School Students in Taiwan. Eurasia Journal of Mathematics, Science and Technology Education, 14: 1239–1252. https://doi.org/10.29333/ejmste/82535

[55] Bereni L, Chauvin S, Jaunait A, et al., 2012, Introduction Aux Études sur le Genre (2nd ed). De Boeck.

[56] Lindberg SM, Hyde JS, Petersen JL, et al., 2010, New Trends in Gender and Mathematics Performance: A Meta-Analysis. Psychological Bulletin, 136(6): 1123–1135. https://doi.org/10.1037/a0021276

[57] Cvencek D, Brečić R, Gaćeša D, et al., 2021, Development of Math Attitudes and Math Self-Concepts: Gender Differences, Implicit-Explicit Dissociations, and Relations to Math Achievement. Child Development, 92(5): e940–e956. https://doi.org/10.1111/cdev.13523

[58] Stetsenko A, Little TD, Gordeeva T, et al., 2000, Gender Effects in Children's Beliefs About School Performance: A Cross-Cultural Study. Child Development, 71(2): 517–527. https://doi.org/10.1111/1467-8624.00161

[59] Chen H-Y, Chen M-F, Lee Y-S, et al., 2013, Gender Reality Regarding Mathematic Outcomes of Students Aged 9 to 15 Years in Taiwan. Learning and Individual Differences, 26: 55–63. https://doi.org/10.1016/j.lindif.2013.04.009

[60] Frey KS, Ruble DN, 1987, What Children Say About Classroom Performance: Sex and Grade Differences in Perceived Competence. Child Development, 58(4): 1066–1078. https://doi.org/10.2307/1130547

[61] Casad BJ, Hale P, Wachs FL, 2015, Parent-Child Math Anxiety and Math-Gender Stereotypes Predict Adolescents' Math Education Outcomes. Frontiers in Psychology, 6: 1597. https://doi.org/10.3389/fpsyg.2015.01597

[62] Genoud PA, Kappeler G, Guillod M, 2015, Attitudes Face Aux Mathématiques: Filles et Garçons Égaux Dans la Façon D'aborder Leurs Apprentissages? Revue Suisse des Sciences de l'Education, 37(2): 301–319. https://doi.org/10.24452/sjer.37.2.4955

[63] Fredricks JA, Eccles JS, 2002, Children's Competence and Value Beliefs from Childhood Through Adolescence: Growth Trajectories in Two Male-Sex-Typed Domains. Developmental Psychology, 38(4): 519–533. https://doi.org/10.1037/0012-1649.38.4.519

[64] Genoud PA, Ruiz G, Gurtner J-L, 2009, Evolution de la Motivation Scolaire des Adolescents: Différences Selon la Filière et le Genre. Revue Suisse des Sciences de l'Education, 31(2): 377–395. https://doi.org/10.24452/sjer.31.2.5100

[65] Frenzel AC, 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): 497–514. https://doi.org/10.1007/bf03173468

[66] Lichtenfeld S, Pekrun R, Stupnisky RH, et al., 2012, Measuring Students' Emotions in the Early Years: The Achievement Emotions Questionnaire-Elementary School (AEQ-ES). Learning and Individual Differences, 22(2): 190–201. https://doi.org/10.1016/j.lindif.2011.04.009

[67] Vanayan M, White N, Yuen P, et al., 1997, Beliefs and Attitudes Toward Mathematics Among Third- and Fifth-Grade Students: A Descriptive Study. School Science and Mathematics, 9(7): 345–351. https://doi.org/10.1111/j.1949-8594.1997.tb17375.x

[68] Mohr-Schroeder MJ, Jackson C, Cavalcanti M, et al., 2017, Parents' Attitudes Toward Mathematics and the Influence on Their Students' Attitudes Toward Mathematics: A Quantitative Study. School Science and Mathematics, 117(5): 214–222. https://doi.org/10.1111/ssm.12225

[69] Neuenschwander MP, Vida M, Garrett JL, et al., 2007, Parents' Expectations and Students' Achievement in Two Western Nations. International Journal of Behavioral Development, 31(5): 474–482. https://doi.org/10.1177/0165025407080589

[70] Yee DK, Eccles JS, 1988, Parent Perceptions and Attributions for Children's Math Achievement. Sex Roles, 19: 317–333. https://doi.org/10.1007/BF00289840

[71] Tomasetto C, Alparone FR, Cadinu M, 2011, Girls' Math Performance Under Stereotype Threat: The Moderating Role of Mothers' Gender Stereotypes. Developmental Psychology, 47(4): 943–949. https://doi.org/10.1037/a0024047

[72] Bleeker MM, Jacobs JE, 2004, Achievement in Math and Science: Do Mothers' Beliefs Matter 12 Years Later? Journal of Educational Psychology, 96: 97–109. https://doi.org/10.1037/0022-0663.96.1.97

[73] Demirtaş AS, Uygun-Eryurt T, 2020, Attachment to Parents and Math Anxiety in Early Adolescence: Hope and Perceived School Climate as Mediators. Current Psychology, 41: 4722–4738. https://doi.org/10.1007/s12144-020-00964-1

[74] Soni A, Kumari S, 2017, The Role of Parental Math Anxiety and Math Attitude in Their Children's Math Achievement. International Journal of Science and Mathematics Education, 15(2): 331–347. https://doi.org/10.1007/s10763-015-9687-5

[75] Casad BJ, Hale P, Wachs FL, 2017, Stereotype Threat Among Girls: Differences by Gender Identity and Math Education Context. Psychology of Women Quarterly, 41(4): 513–529. https://doi.org/10.1177/0361684317711412

[76] Bhanot RT, Jovanovic J, 2005, Do Parents' Academic Gender Stereotypes Influence Whether They Intrude on Their Children's Homework? Sex Roles, 52(9/10): 597–607. https://doi.org/10.1007/s11199-005-3728-4

[77] Grolnick WS, Ryan RM, 1989, Parent Styles Associated with Children's Self-Regulation and Competence in School. Journal of Educational Psychology, 81(2): 143–154. https://doi.org/10.1037/0022-0663.81.2.143

[78] Haladyna T, Shaughnessy J, Shaughnessy JM, 1983, A Causal Analysis of Attitude Toward Mathematics. Journal for Research in Mathematics Education, 14(1): 19–29.

[79] Lafortune L, Mongeau P, Daniel M, et al., 2002, Anxiété à L'égard des Mathématiques. Explication et Mise à L'essai D'une Approche Philosophique, in L'affectivité dans L'apprentissage. Presses de l'Université du Québec, 51–81. https://doi.org/10.2307/j.ctv18ph4c7.6

[80] Mason L, Scrivani L, 2004, Enhancing Students' Mathematical Beliefs: An Intervention Study. Learning and Instruction, 14(2): 153–176. https://doi.org/10.1016/j.learninstruc.2004.01.002

[81] Burnett PC, 2003, The Impact of Teacher Feedback on Student Self-Talk and Self-Concept in Reading and Mathematics. Journal of Classroom Interaction, 38(1): 11–16. https://www.jstor.org/stable/23874243

[82] Li Q, 1999, Teachers' Beliefs and Gender Differences in Mathematics: A Review. Educational Research, 41: 63–76. https://doi.org/10.1080/0013188990410106

[83] Keller C, 2001, Effect of Teachers' Stereotyping on Students' Stereotyping of Mathematics as a Male Domain. Journal of Social Psychology, 141(2): 165–173. https://doi.org/10.1080/00224540109600544

[84] Beilock SL, Gunderson EA, Ramirez G, et al., 2010, Female Teachers' Math Anxiety Affects Girls' Math Achievement. Proceedings of the National Academy of Sciences of the United States of America, 107: 1860–1863. https://doi.org/10.1073/pnas.0910967107

[85] Kunter M, Tsai Y-M, Klusmann U, et al., 2008, Students' and Mathematics Teachers' Perceptions of Teacher Enthusiasm and Instruction. Learning and Instruction, 18(5): 468–482. https://doi.org/10.1016/j.learninstruc.2008.06.008

[86] Frenzel AC, Goetz T, Lüdtke O, et al., 2009, Emotional Transmission in the Classroom: Exploring the Relationship Between Teacher and Student Enjoyment. Journal of Educational Psychology, 101(3): 705–716. https://doi.org/10.1037/a0014695

[87] Szczygieł M, 2020, When Does Math Anxiety in Parents and Teachers Predict Math Anxiety and Math Achievement in Elementary School Children? The Role of Gender and Grade Year. Social Psychology of Education, 23: 1023–1054. https://doi.org/10.1007/s11218-020-09570-2

[88] Furner JM, Gonzalez-DeHass A, 2011, How Do Students' Mastery and Performance Goals Relate to Math Anxiety? Eurasia Journal of Mathematics, Science and Technology Education, 7(4): 227–242. https://doi.org/10.12973/ejmste/75209
[89] Mata MDL, Monteiro V, Peixoto F, 2012, Attitudes Towards Mathematics: Effects of Individual, Motivational, and Social Support Factors. Child Development Research, 2012: 876028. https://doi.org/10.1155/2012/876028
[90] Bussey K, Bandura A, 1999, Social Cognitive Theory of Gender Development and Differentiation. Psychological Review, 106(4): 676–713. https://doi.org/10.1037/0033-295x.106.4.676
[91] Hart SA, Ganley CM, 2019, The Nature of Math Anxiety in Adults: Prevalence and Correlates. Journal of Numerical Cognition, 5(2): 122–139. https://doi.org/10.5964/jnc.v5i2.195
[92] Carraher NT, Carraher DW, Schliemann AD, 1985, Mathematics in the Street and in Schools. British Journal of Developmental Psychology, 3: 22–29. https://doi.org/10.1111/j.2044-835X.1985.tb00951.x
[93] Saxe GB, 1988, The Mathematics of Child Street Vendors. Child Development, 59: 1415–1425. https://doi.org/10.2307/1130503
[94] Boekaerts M, 1999, Motivated Learning: Studying Student * Situation Transactional Units. European Journal of Psychology of Education, 14(1): 41–55. https://doi.org/10.1007/bf03173110
[95] Op't Eynde P, De Corte E, Verschaffel L, 2001, "What to Learn from What We Feel?": The Role of Student's Emotion in the Mathematics Classroom, in Motivation in Learning Contexts: Theoretical Advances and Methodological Implication. Pergamon Press, 149–167.
[96] Ambady N, Shih M, Kim A, et al., 2001, Stereotype Susceptibility in Children: Effects of Identity Activation on Quantitative Performance. Psychological Science, 12: 385–390. https://doi.org/10.1111/1467-9280.00371
[97] Morin-Messabel C, Ferrière S, 2008, Contexte Scolaire, Appartenance Catégorielle de Sexe et Performances. De la Variation de L'habillage de la Tâche sur les Performances à L'école Élémentaire. Cahiers Internationaux de Psychologie Sociale, 80(4): 13–26. https://doi.org/10.3917/cips.080.0013
[98] Huguet P, Brunot S, Monteil J-M, 2001, Geometry Versus Drawing: Changing the Meaning of the Task as a Means to Change Performance. Social Psychology of Education, 4: 219–234. https://doi.org/10.1023/A:1011374700020
[99] Rowley SJ, Kurtz-Costes B, Mistry R, et al., 2007, Social Status as a Predictor of Race and Gender Stereotypes in Late Childhood and Early Adolescence. Social Development, 16(1): 150–168. https://doi.org/10.1111/j.1467-9507.2007.00376.x
[100] Schmader T, Johns M, Forbes C, 2008, An Integrated Process Model of Stereotype Threat Effects on Performance. Psychological Review, 115: 336–356. https://doi.org/10.1037/0033-295X.115.2.336
[101] Osborne JW, 2001, Testing Stereotype Threat: Does Anxiety Explain Race and Sex Differences in Achievement? Contemporary Educational Psychology, 26: 291–310. https://doi.org/10.1006/ceps.2000.1052
[102] Croizet JC, Despres G, Gauzins ME, et al., 2004, Stereotype Threat Undermines Intellectual Performance by Triggering a Disruptive Mental Load. Personality and Social Psychology Bulletin, 30: 721–731. https://doi.org/10.1177/0146167204263961
[103] Halim M, Ruble DN, Amodio DM, 2011, From Pink Frilly Dresses to 'One of the Boys': A Social-Cognitive Analysis of Gender Identity Development and Gender Bias. Social and Personality Psychology Compass, 5: 933–949. https://doi.org/10.1111/j.1751-9004.2011.00399.x
[104] Smeding A, Dumas F, Loose F, et al., 2013, Order of Administration of Math and Verbal Tests: An Ecological Intervention to Reduce Stereotype Threat on Girls' Math Performance. Journal of Educational Psychology, 105(3): 850–860. https://doi.org/10.1037/a0032094
[105] Shih M, Pittinsky TL, Ambady N, 1999, Stereotype Susceptibility: Identity Salience and Shifts in Quantitative Performance. Psychological Science, 10: 80–83. https://doi.org/10.1111/1467-9280.00111

[106] Steele CM, Aronson J, 1995, Stereotype Threat and the Intellectual Test Performance of African Americans. Journal of Personality and Social Psychology, 69: 797–811. https://doi.org/10.1037/0022-3514.69.5.797

[107] Malmivuori M-J, 2007, Affect and Self-Regulation. Educational Studies in Mathematics, 63(2): 149–164. https://doi.org/10.1007/s10649-006-9022-8

[108] Griggs MS, Rimm-Kaufman SE, Merritt EG, et al., 2013, The Responsive Classroom Approach and Fifth Grade Students' Math and Science Anxiety and Self-Efficacy. School Psychology Quarterly, 28(4): 360–373. https://doi.org/10.1037/spq0000026

[109] Meyer DK, Turner JC, 2002, Discovering Emotion in Classroom Motivation Research. Educational Psychologist, 37(2): 107–114. https://doi.org/10.1207/S15326985EP3702_5

[110] De Corte E, Depaepe F, Op't Eynde P, et al., 2011, Students' Self-Regulation of Emotions in Mathematics: An Analysis of Meta-Emotional Knowledge and Skills. ZDM: The International Journal on Mathematics Education, 43(4): 483–495. https://doi.org/10.1007/s11858-011-0333-6