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Changes in high-school students' competence beliefs, utility value and achievement goals in mathematics

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Background. Many studies have revealed that there is a significant decrease over time in high-school students' attitudes towards mathematics learning. Some authors conclude that motivation in mathematics stabilizes or improves around grade 9; others propose that the decline is continuous. It is unclear if girls or boys are more affected by this phenomenon.

Aims. The present study aims to further examine changes in competence beliefs, utility value and achievement goals in mathematics during high school, taking gender and period of the academic year into account.

Sample. 1,130 participants from 18 secondary schools, distributed in two cohorts (grades 7 and 9).

Method. Attitudinal scales designed to measure competence beliefs, utility value and achievement goals in mathematics were administered at the beginning and end of three academic years in a longitudinal cohort-sequential research design using two sequential cohorts. Hierarchical linear modelling was used to analyse the data.

Results. Results showed an ongoing reduction of most of the variables measured. This was the case for both cohorts and genders. However, boys were more affected than girls. Furthermore, for all variables, motivation tended to be lower at the end of the academic year than at the beginning.

Conclusions. Our results support the hypothesis of a regular decline of motivation in mathematics during high school, accentuated between grades 9 and 11. Moreover, our results illustrate gender convergence in mathematics rather than gender differentiation. Finally, the gradual drop in motivation in mathematics appears to be a two-step phenomenon: a decrease between and within grade levels.

Many studies have revealed that there is a significant change in students' attitudes towards the learning of mathematics over time (Eccles *et al.*, 1985; Fredricks & Eccles, 2002; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Ma & Cartwright, 2003; Stipek,

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1993; Watt, 2004). According to these authors, many high-school students appear less optimistic with respect to their chances to succeed in this domain and acknowledge a significant decrease in the value they ascribe to mathematics. These types of changes also appear to be associated with gender and earlier studies have found that the decrease in positive attitudes towards mathematics affects girls more than boys (Eccles *et al.*, 1985; Fennema & Sherman, 1977; Stodolsky, 1985). Unfortunately, very few studies have examined the changes in achievement goals during adolescence. Moreover, while some studies conclude that motivation towards mathematics stabilizes or improves around grade 9, others suggest that the decline is continuous throughout high school. Therefore, the purpose of the present study was to further examine the changes of high-school boys' and girls' competence beliefs, utility value and achievement goals in mathematics.

Expectancy, value and achievement goals

The Expectancy-value theories have been used in the last few years as a conceptual framework in a number of important studies on achievement motivation. According to these theories, engagement and achievement are best predicted by the combination of students' expectations and the value attributed to success (Eccles, Wigfield, & Schiefele, 1998; Pintrich & Schrauben, 1992; Pintrich & Schunk, 1996). Generally, the expectancy components of most of these theories correspond to the students' beliefs about how well they will perform on upcoming tasks and relate to their perception of being able to carry out their academic projects successfully. The Value components refer to students' interest in the given tasks and in the utility value ascribed to the domain (Pintrich & Schrauben, 1992).

Motivation researchers have also become interested in students' achievement goals. Initial goal theory suggests that there are two general goal orientations and, although there are slight theoretical variations between authors in the definition of these labels, they will be referred to here as mastery and performance goals for clarity. A mastery goal orientation reflects an emphasis on learning and understanding, whereas a performance orientation focuses on demonstrating competence in relation to others (Ames, 1992; Linnenbrink & Pintrich, 2002). Nonetheless, for several years some authors have reported that the effect of performance goals differs according to self-perceptions and research has shown that mastery and performance goals are not necessarily mutually exclusive. In fact, the desire to reach a high level of achievement is not always incompatible with the pursuit of high levels of mastery and performance goals, which can have some positive functions (Bouffard, Boisvert, Vezeau, & Larouche, 1995). As a result, several authors have proposed an expansion of the theory towards a *multiple goals perspective*. A 2 × 2 model developed by Elliot and McGregor (2001) states that there are four types of achievement goals. Mastery-approach goals focus on learning and task mastery, while mastery-avoidance goals focus on the avoidance of not learning or not mastering a task; performance-approach goals focus on the attainment of favourable judgments of competence, while performance-avoidance goals focus on the avoidance of unfavourable judgments of competence.

Alternatively, certain authors suggest that for some students, the ultimate goal is to invest a minimum of effort (Bouffard, Vezeau, Romano, Chouinard, Bordeleau, & Filion, 1998; Meece & Holt, 1993). Therefore, they propose a *trichotomous* achievement goals model comprising mastery (approach) goals, performance (approach) goals and work-avoidance goals. According to this model, students who pursue work-avoidance goals

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tend to work as little as possible, appreciating easy success and aiming only to reach a passing grade. Measures of work-avoidance show high reliability and research indicates that it can be separated from both mastery and performance-approach goal orientations (Seifert & O'Keefe, 2001; Skaalvik, 1997). This is the theoretical model retained for the purpose of the present study.

Motivational gender-related differences in mathematics and transformations over time

Many studies have underlined the existence of differences between boys' and girls' motivation in mathematics. These differences are also observed in other school subjects, notably in sciences, but are more pronounced and consistent in mathematics. When compared to boys with similar achievement levels, girls often demonstrate more anxiety and lower competence beliefs (Anderman & Midgley, 1997; Eccles *et al.*, 1985; Kloosterman, 1990; Seegers & Boekaerts, 1996; Stipek & Gralinski, 1991; Watt, 2004; Wolters, Yu, & Pintrich, 1996). Some authors hypothesize that girls' lower competence beliefs in mathematics could be explained by the fact that they tend to attribute success to determined efforts, help from others or task ease and perceive their difficulties as due to a lack of ability (Stipek & Gralinski, 1991). On the contrary, boys are inclined to attribute success to ability and failure to transitory external causes such as bad luck or the lack of help (Hackett & Betz, 1992; Randhawa, Beamer, & Lundberg, 1993). Moreover, Watt states that intrinsic value for mathematics is characterized by a consistent gender difference favouring boys. Moreover, while boys report higher mean levels of performance-approach goals than girls do, both genders are as oriented towards mastery goals in mathematics (Anderman & Midgley, 1997; Kaplan & Midgley, 1997; Seegers & Boekaerts, 1996). However, recent findings indicate that girls value mathematics as much as boys do (De Corte & Op't Eynde, 2003; Frenzel, Pekrun, Goetz, & von Hofe, 2005; Greene, De Backer, Ravindran, & Krows, 1999; Mason, 2003), which is inconsistent with the findings of the past decades.

Research has also demonstrated that there is a significant change in students' attitudes towards mathematics learning over time (Eccles *et al.*, 1985; Fredricks & Eccles, 2002; Stipek, 1993; Watt, 2004). According to these studies, many students appear to be less optimistic over time with respect to their chances to succeed in this domain (Watt, 2004) and show a significant decline in their competence beliefs (Anderman & Midgley, 1997; Jacobs *et al.*, 2002). At the same time, there is a gradual increase in anxiety when faced with situations associated with mathematics (Ma & Cartwright, 2003). Therefore, even though they still consider mathematics to be an important subject, many students develop negative attitudes towards this domain and begin to question its usefulness. Several studies also indicate that intrinsic value for mathematics declines through junior high school (Eccles (Parsons) *et al.*, 1983; Jacobs *et al.*, 2002).

However, the question of gender-related differences in mathematics and the question of the decrease of motivation in this domain during high school are controversial. Earlier studies have found that the decrease in positive attitudes towards mathematics affects girls more than boys (Eccles *et al.*, 1985; Fennema & Sherman, 1977; Stodolsky, 1985). Several explanations have been proposed to account for these results. Firstly, boys may present more ability in certain mathematical tasks such as problem solving and this, in-turn, may positively affect their commitment towards this discipline (Fennema & Sherman, 1977; Leder, 1990). Secondly, parents and teachers

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might encourage boys more than girls to take advanced mathematics courses (Duru-Belat, 1995; Eccles, 1987). Finally, many girls may believe that mathematics is a male domain, which therefore could conflict with their gender identification (Fennema & Sherman, 1977). More recently, Watt (2004) has found that boys maintain consistently higher self-perceptions than girls in mathematics throughout grades 7–11 with little evidence for gender intensification or gender convergence. Moreover, high-school boys' expectancies for success remained relatively stable, whereas girls' displayed a curvilinear pattern, in which their expectancies declined through junior high then rose again in senior years, although not to the same level as at the outset of high school. The same researcher has also found that, in contrast, boys and girls had similar mathematics utility value, which declined through secondary school with the extent of decline becoming greater over time. In contrast, Fredericks and Eccles (2002) have found that both high-school boys and girls reported a continuous decline in the perception of their mathematics competencies. However, girls' perceptions of their mathematics ability declined at a slower rate than the boys' perceptions did. Furthermore, their results indicated no significant decline in high-school students' perceptions of the importance of mathematics, and no gender effect. Ma and Cartwright (2003), for their part, stated that their hierarchical linear models indicated no statistically significant gender differences in the rate of decline in either self-perceptions or utility towards mathematics during middle and high school.

Very few studies have examined the changes in achievement goals in mathematics across middle and high school, in part due to the recent reformulations of the goal theory. Anderman and Midgley (1997) report that, in their longitudinal study, students were more oriented towards mastery goals in grade 5 in elementary school than in grade 6 in middle school. Moreover, they identified a greater emphasis on performance goals in grade 6. However, this study did not include the avoidance component of performance goals. Skaalvik (1997) incorporated performance-avoidance goals in his study and found stability in all achievement goals across middle school. Wolters *et al.* (1996) examined middle school students' achievement goals in mathematics at the beginning and end of the academic year and found moderate stability for mastery goals and high stability for both performance goals (approach and avoidance). Following their longitudinal study with grades 7 and 9 students, Middleton, Kaplan, and Midgley (2004) indicate that mastery-approach goals and each component of performance goals orientation were moderately stable over time.

The present study

Despite the well-documented decrease in high-school students' motivation, there are several reasons to further examine the motivational changes in mathematics during adolescence. Firstly, very few studies have examined the evolution of achievement goals in mathematics across middle and high school within a longitudinal research scheme, involving growth curve modelling. Secondly, the results obtained on the relative gendered differential changes in mathematics motivation remain inconsistent because certain authors obtain results which favour boys, while others maintain that the distinctions between the students of both genders tend to become negligible. Moreover, it is unclear if the changes observed recently in the motivational patterns of boys and girls are permanent, temporary or simply due to variations in the samples used in different studies. Furthermore, only a few studies examined the transformations of competence beliefs, utility value and achievement goals in a single sample and with

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measurements at the beginning and end of each academic year. Finally, it is unclear if mathematics motivation declines at an accelerated rate, stabilizes or increases in the last years of high school. Therefore, the present study intended to address the hypothesis that there is a general breakdown of students' competence beliefs, utility value and achievement goals in mathematics during adolescence. Moreover, it aimed to examine the evolution of these variables according to gender, to test their cross-year fluctuations, and to verify if the decline of motivation towards mathematics accelerates, stabilizes or improves in the last years of high school.

Method

Participants

Data were collected twice yearly from students who were attending 18 French-speaking public and private high schools in the Montreal area (Quebec, Canada). All participants were enrolled in regular mathematics classes. It is important to note here that secondary school in Quebec comprises grades 7–11. In order to span these grades, an overlapping cohort longitudinal design was adopted. Thus, the participants in the first cohort were in grade 7 at the beginning of the study and followed till the end of grade 9, while participants in the second cohort were in grade 9 at the beginning of the study and followed till the end of their grade 11. This presents an overlap of the two cohorts at the two periods of measurement in grade 9 and provided satisfactory control over possible cohort effects. The initial sample comprised 1,329 students who were distributed in the two cohorts on the basis of their grade at the beginning of the study. The first cohort consisted of 704 grade 7 students ($N = 277$ males and 427 females; mean age $= 12.85$, $SD = 0.83$), while the second cohort consisted of 625 grade 9 students ($N = 259$ males and 366 females; mean age $= 14.85$, $SD = 0.83$). Thus, the two cohorts were similar in terms of gender and contained approximately the same number of participants and the same gender proportion (females 61 and 59%; males 39 and 41%, respectively).

Procedure

Participants were followed during three academic years. Several self-reported attitude scales from different sources were compiled into one questionnaire measuring the following variables: competence beliefs, utility value, mastery-approach goals, performance-approach goals and work-avoidance goals. This questionnaire took approximately 40 minutes to complete and was administered twice a year, in October and May (later referred to as the periods of measurement A and B). Hence, over the 3-year period, each participant completed the same questionnaire six times. The questionnaire was completed during students' mathematics classes, which helped reduce attrition.

Measures

Several self-reported scales were used to assess participants' motivation in mathematics. All these scales reveal satisfactory levels of reliability and consistency in the French version that was used for the purpose of the study.

Participants' competence beliefs in mathematics were measured using a subscale of six items drawn from the *Perceived Competence Scale* developed by Harter (1982), translated and validated in French by Pierrehumbert, Zazone, Kauer-Tchicaloff, and

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Plancherel (1988). It enables the assessment of the participants' evaluation of their competence in mathematics using opposing bipolar statements on which the respondent has to make a self-related choice (e.g. 'Some students think that they are very good in mathematics but others wonder if they can do their work') ($\alpha = .81$). Utility value was assessed by a subscale from the Fennema-Sherman's Mathematics Attitudes Scales (1976), translated and validated in French by Vezeau, Chouinard, Bouffard, and Couture (1998). It incorporates six items ($\alpha = .81$) measuring participants' perceptions of present or future usefulness of mathematics (e.g. 'What I learn in maths will be useful in my adult life'). Achievement goals in mathematics were measured by an instrument produced and validated by Bouffard *et al.* (1998) according to their *trichotomous* model of achievement goals including work-avoidance. The mastery-approach goals subscale ($\alpha = .90$) entailed eight statements assessing the extent to which participants wished to master the content of their mathematics courses (e.g. 'In mathematics, I like difficult activities that permit me to acquire new knowledge'). The performance-approach goals subscale ($\alpha = .75$) consisted of eight statements measuring the degree to which participants set personal goals to be among the best in their class and to obtain high marks in mathematics (e.g. 'In mathematics, I compete with others to get higher marks'). The work-avoidance goals subscale ($\alpha = .73$) comprised seven statements measuring the degree to which participants set their goals to do the least possible work to pass (e.g. 'In mathematics, I do not work much on activities that are not considered for the final grades').

Items from most scales were rated on a five-point Likert-type scale, ranging from 1 ('Strongly disagree') to 5 ('Strongly agree'). Judgments on the subscale measuring competence beliefs are expressed on a four-point scale ranging from 'Totally like me' to 'Totally unlike me'.

Analysis

Analyses pertaining to this study were conducted using hierarchical linear modelling (HLM), a multi-level procedure that allows for modelling change over time (Bryk & Raudenbush, 2002). Unlike traditional repeated models or ANOVA, growth models use all available information for each respondent and none of them is excluded on the basis of missing sequence data. Hence, multi-level procedure makes generalizations from this data set possible, whereas a sample comprised only of participants with all six follow-up data points would have been much smaller and would have reduced statistical power (Walter-Barnes & Mason, 2001). Another advantage of HLM over traditional regression models is that it allows to model the initial outcome at the start of the study (the intercept) and the degree of change over time (the slope) for each individual participant. In this particular case, it allowed for consideration of the effect of time, cohort and gender on the development of motivation towards mathematics. Moreover, it also made it possible to control for the period of measurement (start or end of each academic year). Finally, HLM is not sensitive to the assumption of sphericity or compound symmetry.

Results

To assess the relations between the variables, we first computed correlations among cohort 1 participants' gender, competence beliefs, utility value and mastery-approach, performance-approach and work-avoidance goals at the outset of the study. In addition,

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we computed correlations among cohort 2 participants' scores to examine the differences in these relations between the two cohorts. Table 1 gives these correlations and also the means and standard deviations for each variable. Results indicate strong correlations between competence beliefs, utility value and achievement goals. There was little evidence that the direction or strength of the relations between the variables were different from one cohort to the other.

Table 1. Descriptives and bivariate correlations among participants of cohort 1 and 2 at the outset of the study

	Cohort 1 (grades 7 to 9)						
Variable	1	2	3	4	5	*M*	*SD*
1. Competence beliefs	1	.26***	.36***	.32***	−.35***	2.88	0.64
2. Utility value	.33***	1	.61***	.22***	−.44***	4.20	0.72
3. Mastery-approach goals	.39***	.66***	1	.29***	−.55***	4.20	0.67
4. Performance-approach goals	.37***	.36***	.38***	1	−.14***	3.24	0.75
5. Work-avoidance goals	−.28***	−.42***	−.58***	−.08*	1	2.54	0.69
M	2.83	4.22	3.99	3.23	2.61		
SD	0.62	0.69	0.67	0.72	0.67		
	Cohort 2 (grades 9 to 11)						

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

We then performed HLM analyses individually on each motivational variable retained. Approximately 60% of the participants in each cohort were present for all the sequences of data, and approximately 25% missed only one sequence. Attrition in the sample was mostly due to students changing to a non-participating school or to students who were absent from school when the data were collected. Participants who had missed more than one sequence were removed from the analyses, which left a total of 1,130 participants. First, a base-level model was tested for each of the five dependent variables (competence beliefs, utility value, mastery and performance-approach and work-avoidance goals). It is relevant to note that the participants of both cohorts (cohort 1 = grades 7 to 9; cohort 2=grades 9 to 11) filled out the questionnaire twice during the academic years (autumn = a; spring = b). This first model was a simple, one level HLM model, with time as the only predictor in the equation. Considering the presence of two cohorts which overlap on the grade 9 and that we collected the results twice per year, the intercept was centred at the beginning of grade 9 and dummy variables were created for the other time points. Therefore, the base model merely considered the coefficient at the beginning of the study and the variation in time and hence, offered important initial information about the motivation levels of the participants. In this model, b0 represents the initial value of the dependent variable at the beginning of the study, b1 the variations in time and *R* the variance residual term:

$$Y = b0 + b1^{*}(\text{Time}) + R$$

Since this first model revealed a significant effect of time on most dependent variables retained ($p < .05$), a more complex two-level model was constructed. Level 1 expresses the dependent variable in relation to the explanatory variable that varies for individuals

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(time of measurement). Level 2 consists of explanatory variables that do not changeover time because they are inherently stable (gender and cohort). The coefficients b0 to b9 represent dummy variables for each time of measurement. The coefficients g01, g11, g21, g31 and g41 indicate the adjustment made for gender for each grade level, with g01 reflecting the difference between males and females in grade 9, and g11 to g41 reflecting differences between males and females in, respectively, grades 7, 8, 10 and 11 in comparison with scores obtained in grade 9. Moreover, coefficients g51, g61, g71, g81 and g91 indicate the adjustment made for gender when considering differences between periods of measurement (the beginning and the end of each grade level). Coefficient g2 expresses the differences between the two cohorts at the reference point (grade 9) and coefficient g72 expresses the adjustment for cohort when considering differences between measurement periods at the reference point. As gender is a dummy variable with 0 ascribed to males and 1 to females, positive values indicate higher means and slopes for females than for males. Thus, the complete equation of the second model is the following:

$$
\begin{aligned}
[\gamma] = {} & b0 + b1^{*}(\text{grade } 7) + b2^{*}(\text{grade } 8) + b3^{*}(\text{grade } 10) + b4^{*}(\text{grade } 11) \\
& + b5^{*}(\Delta\text{beginning} - \text{end of grade } 7) + b6^{*}(\Delta\text{beginning} - \text{end of grade } 8) \\
& + b7^{*}(\Delta\text{beginning} - \text{end of grade } 9) + b8^{*}(\Delta\text{beginning} - \text{end of grade } 10) \\
& + b9^{*}(\Delta\text{beginning} - \text{end of grade } 11)
\end{aligned}
$$

$$b0 = g00 + g01^{*}(\text{Gender}) + g02^{*}(\text{cohort}) + u0$$

$$b1 = g10 + g11^{*}(\text{Gender})$$

$$b2 = g20 + g21^{*}(\text{Gender})$$

$$b3 = g30 + g31^{*}(\text{Gender})$$

$$b4 = g40 + g41^{*}(\text{Gender})$$

$$b5 = g50 + g51^{*}(\text{Gender})$$

$$b6 = g60 + g61^{*}(\text{Gender})$$

$$b7 = g70 + g71^{*}(\text{Gender}) + g72^{*}(\text{cohort})$$

$$b8 = g80 + g81^{*}(\text{Gender})$$

$$b9 = g90 + g91^{*}(\text{Gender})$$

The between-class variance estimates from the first and the second model were compared and the second model showed significant improvement of the estimation of variance components of each dependent variable. This improvement ranges from 0.40% to 19.32% on the Level 1 variance residual term (*R*), from 5.22% to 23.30% on u0 and from 2.57% to 16.03% on u1. Moreover, the deviance score of the second model is slightly lower than the deviance of the first model (.11% to 3.41%), which indicates that

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the second model fits the data better (Hox, 2002), even if the significant chi-squared estimates of between-class variance in both models suggest that a significant proportion of the variance remained unexplained. Thus, the second model was retained for the study. Grade 9 being common to both cohorts, this grade level was retained as a reference point to which the means obtained at each other grade level were compared (grades 7, 8, 10 and 11).

Competence beliefs

The first set of analyses examined gender differences in the trajectories for competence beliefs in the domain of mathematics. On the basis of previous research, competence beliefs were expected to be highest in grade 7 and to decline across the academic years. As shown in Table 2 and Figure 1, there was a base score of 2.87 out of a possible score of 4 in grade 9. No differences were found between grades 7, 8 and 9, indicating that competence beliefs were stable across these grade levels. Males reported higher competence beliefs in mathematics than females at the initial time point but the gap between males and females tended to diminish in grades 10 and 11. Therefore, results revealed that competence beliefs only decreased for males while increasing slightly for females in grades 9–11. Moreover, significant effects for the period of measurement (beginning or end of the academic year) were found. Therefore, competence beliefs were significantly higher for both genders at the beginning than at the end of grades 7, 8 and 10. No differences between the two cohorts emerged.

Table 2. Coefficients for competence beliefs

	Estimation of intercept and slope				Estimation of intercept and slope		
Predictor	Υ	*SE*	*t*	Predictor	Υ	*SE*	*t*
Grade 9 (Base of comparison)				Δbeginning-end 9th			
Base	2.87	0.03	93.59***	Base	−0.03	0.02	−1.75
Gender	−0.18	0.04	−4.92***	Gender	0.02	0.02	0.99
Cohort	−0.04	0.04	−1.21	Cohort	−0.03	0.02	−1.42
Grade 7				Δbeginning-end 7th			
Base	0.04	0.02	1.81	Base	−0.07	0.03	−2.82**
Gender	0.01	0.03	0.30	Gender	0.02	0.03	0.53
Grade 8				Δbeginning-end 8th			
Base	0.04	0.03	1.10	Base	−0.15	0.04	−3.56**
Gender	0.04	0.04	0.89	Gender	0.03	0.05	0.53
Grade 10				Δbeginning-end 10th			
Base	−0.02	0.03	−0.78	Base	−0.08	0.04	−2.26*
Gender	0.05	0.04	1.36	Gender	0.06	0.05	1.19
Grade 11				Δbeginning-end 11th			
Base	−0.09	0.05	−2.03*	Base	−0.06	0.06	−0.97
Gender	0.12	0.06	2.24*	Gender	0.04	0.07	0.60

Estimation of between-class variance		
	df	χ^2
Intercept	1,154	27,009.27***

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

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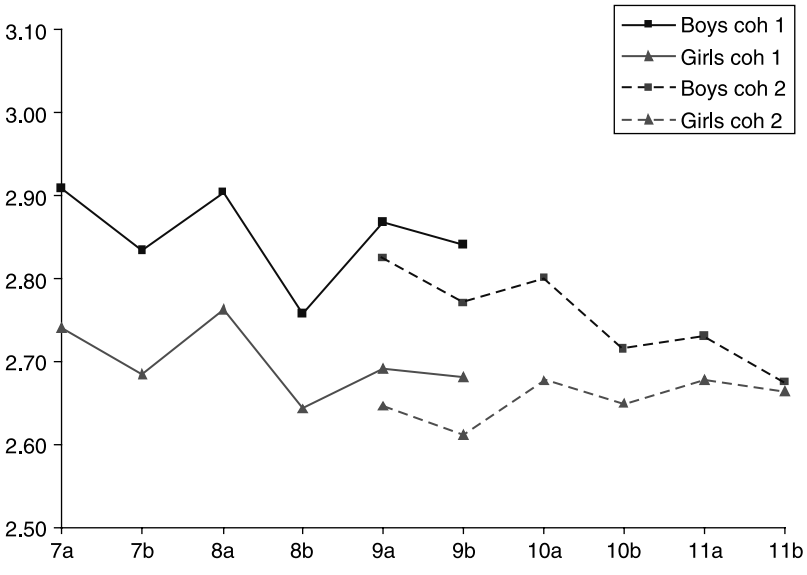


Figure 1. Changes of competence beliefs.

Utility value

The base coefficient for this variable was 4.09. HLM analyses revealed a significant time effect (in grades 7 and 11), suggesting a decline in the utility value ascribed to mathematics over time for males and females. An interaction effect indicates that this was more pronounced for males than for females in the grade 11. Results also show a period effect in grades 7, 8 and 10, revealing that utility value of mathematics is lower at the end of those grade levels than at the beginning. This indicates that the equation and growth curve show a non-linear relationship. No differences between the two cohorts were found. Table 3 and Figure 2 present these results.

Mastery-approach goals

The base coefficient for mastery-approach goals is 3.97 but cohort 2 reported a lower score (3.86). Moreover, a gender effect was identified, females expressing higher mastery-approach goals than males throughout the study. Results show a time effect which indicates that grade 7 participants reported significantly higher scores for mastery goals than grade 9 students, while grade 11 participants expressed lower mastery-approach goals than grade 9 participants. This last result underlines a gradual drop in mastery-approach goals through high school for both genders. Moreover, results indicate that mastery-approach goals were lower at the end of the grade level than at the beginning in grades 7, 8 and 10 for both genders and for males in grade 11. Results also indicate that cohort 2 reported a decrease of mastery-approach goals in grade 9. Once again, these results suggest that the equation and growth curve might show a non-linear relationship. Table 4 and Figure 3 illustrate these results.

Performance-approach goals

As shown in Table 5 and Figure 4, the basic coefficient for performance-approach goals is 3.22, which remained stable throughout the study. Base comparison results reveal a

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Table 3. Coefficients for utility value

	Estimation of intercept and slope				Estimation of intercept and slope		
Predictor	Υ	*SE*	*t*	Predictor	Υ	*SE*	*t*
Grade 9 (Base of comparison)				Δbeginning-end 9th			
Base	4.09	0.04	115.97***	Base	−0.03	0.02	−1.24
Gender	0.07	0.04	1.75	Gender	0.00	0.02	0.08
Cohort	−0.05	0.04	−1.25	Cohort	−0.04	0.02	−1.67
Grade 7				Δbeginning-end 7th			
Base	0.09	0.03	3.12**	Base	−0.18	0.04	−5.12***
Gender	−0.03	0.04	−0.76	Gender	0.12	0.05	2.65**
Grade 8				Δbeginning-end 8th			
Base	−0.01	0.04	−0.17	Base	−0.21	0.06	−3.80***
Gender	0.04	0.05	0.76	Gender	0.08	0.07	1.23
Grade 10				Δbeginning-end 10th			
Base	−0.07	0.04	−1.75	Base	−0.19	0.05	−3.82***
Gender	−0.02	0.05	−0.41	Gender	0.07	0.07	0.99
Grade 11				Δbeginning-end 11th			
Base	−0.38	0.06	−6.09***	Base	−0.01	0.08	−0.12
Gender	0.15	0.07	2.04*	Gender	−0.12	0.09	−1.31

Estimation of between-class variance

	df	χ^2
Intercept	1,154	19,014.01

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

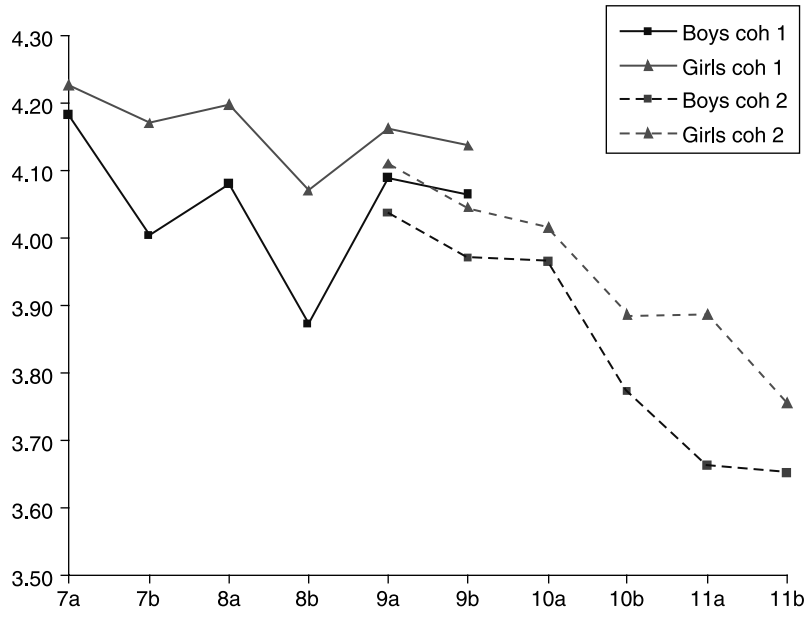


Figure 2. Changes of utility value.

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Table 4. Coefficients for mastery-approach goals

	Estimation of intercept and slope				Estimation of intercept and slope		
Predictor	Υ	*SE*	*t*	Predictor	Υ	*SE*	*t*
Grade 9 (Base of comparison)				Δbeginning-end 9th			
Base	3.97	0.03	114.60***	Base	−0.02	0.02	−0.83
Gender	0.09	0.04	2.10*	Gender	0.01	0.02	0.29
Cohort	−0.11	0.04	−2.73**	Cohort	−0.05	0.02	−2.20*
Grade 7				Δbeginning-end 7th			
Base	0.15	0.03	5.53***	Base	−0.19	0.03	−5.98***
Gender	−0.02	0.04	−0.60	Gender	0.04	0.04	1.04
Grade 8				Δbeginning-end 8th			
Base	0.04	0.04	1.04	Base	−0.21	0.05	−4.20***
Gender	−0.02	0.05	−0.33	Gender	0.08	0.06	1.24
Grade 10				Δbeginning-end 10th			
Base	0.01	0.04	0.15	Base	−0.21	0.05	−4.61***
Gender	−0.02	0.05	−0.41	Gender	0.06	0.06	1.02
Grade 11				Δbeginning-end 11th			
Base	−0.13	0.06	−2.37*	Base	−0.23	0.68	−3.37***
Gender	−0.01	0.07	−0.18	Gender	0.20	0.08	2.42*

Estimation of between-class variance

	df	χ^2
Intercept	1,154	23,599.61

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

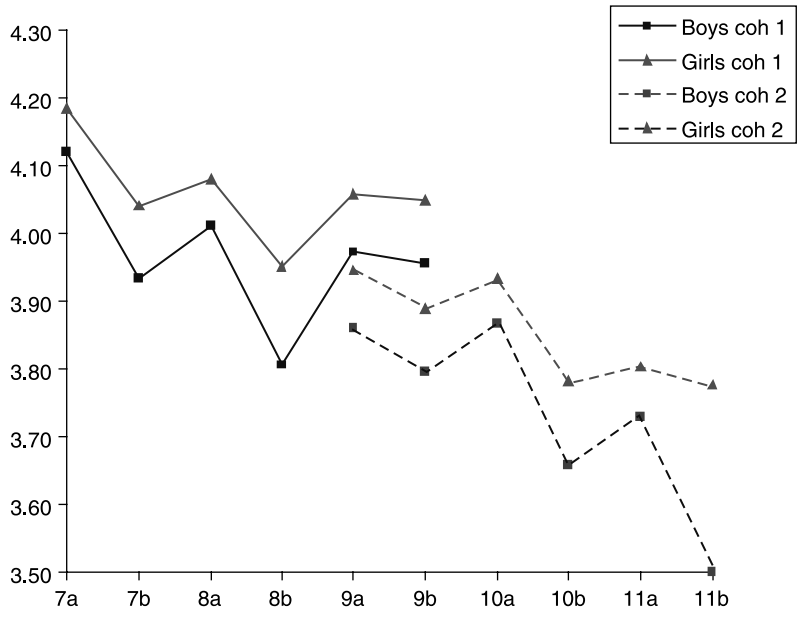


Figure 3. Changes of mastery-approach goals.

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Table 5. Coefficients for performance-approach goals

	Estimation of intercept and slope				Estimation of intercept and slope		
Predictor	Υ	*SE*	*t*	Predictor	Υ	*SE*	*t*
Grade 9 (Base of comparison)				Δbeginning-end 9th			
Base	3.22	0.03	94.75***	Base	−0.01	0.02	−0.66
Gender	−0.16	0.04	−4.08***	Gender	0.01	0.02	0.53
Cohort	0.04	0.04	1.07	Cohort	−0.06	0.02	−2.91**
Grade 7				Δbeginning-end 7th			
Base	0.01	0.03	0.42	Base	−0.07	0.03	−2.17*
Gender	0.06	0.03	1.87	Gender	−0.06	0.04	−1.41
Grade 8				Δbeginning-end 8th			
Base	0.01	0.04	0.36	Base	−0.02	0.05	−0.31
Gender	−0.05	0.05	−1.10	Gender	−0.03	0.06	−0.58
Grade 10				Δbeginning-end 10th			
Base	0.04	0.04	1.12	Base	−0.14	0.04	−3.25**
Gender	−0.07	0.05	−1.39	Gender	0.07	0.06	1.18
Grade 11				Δbeginning-end 11th			
Base	−0.09	0.05	−1.66	Base	−0.15	0.07	−2.18*
Gender	0.05	0.07	0.74	Gender	0.04	0.08	0.46

Estimation of between-class variance

	df	χ^2
Intercept	1,154	23,332.29

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

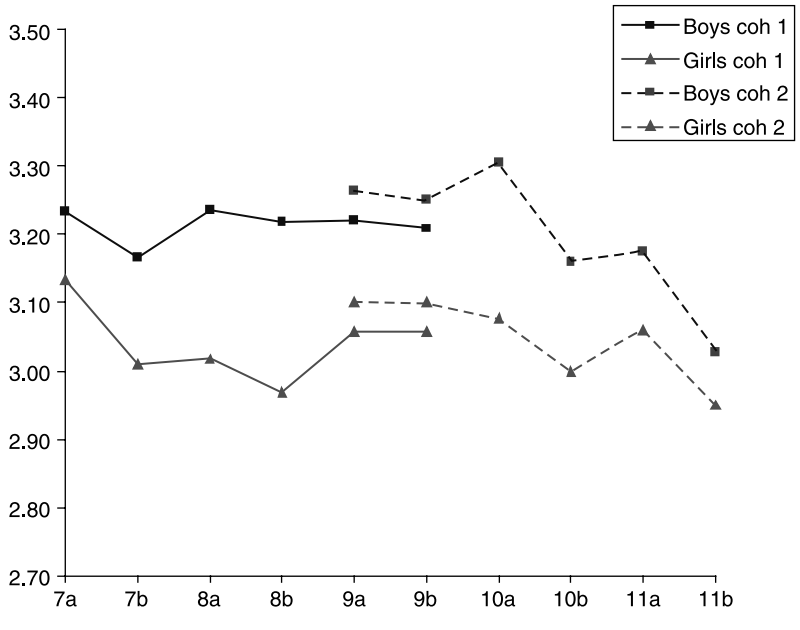


Figure 4. Changes of performance-approach goals.

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gender difference. Thus, females' performance-approach goals were significantly lower than those of males across grade levels. Furthermore, results demonstrate that performance-approach goals were generally lower at the end of the grade levels than at the beginning in grades 7, 10 and 11 for participants of cohort 1, and in grade 9 for participants of cohort 2.

Work-avoidance goals

The basic coefficient for work-avoidance goals was 3.22. Results indicate that females expressed lower work-avoidance goals than males across all grade levels; subtracting 0.25 to females' mean base score. Work-avoidance goals appear to be moderately stable across grade levels, being slightly lower in grades 8 and 10 than in grade 9. Nonetheless, results show that work-avoidance goals tend to be higher at the end of the grade levels than at the beginning, for both genders in grades 7, 8 and 10 and for males in grade 11. These results are shown in Table 6 and Figure 5.

Table 6. Coefficients for work-avoidance goals

	Estimation of intercept and slope				Estimation of intercept and slope		
Predictor	γ	*SE*	*t*	Predictor	γ	*SE*	*t*
Grade 9 (Base of comparison)				Δbeginning-end 9th			
Base	2.78	0.03	98.05***	Base	0.02	0.02	−0.84
Gender	−0.25	0.04	6.48***	Gender	−0.03	0.02	1.43
Cohort	−0.03	0.04	0.68	Cohort	0.00	0.02	0.04
Grade 7				Δbeginning-end 7th			
Base	−0.04	0.03	1.55	Base	0.10	0.03	−2.92**
Gender	0.03	0.04	−0.80	Gender	−0.06	0.04	1.40
Grade 8				Δbeginning-end 8th			
Base	−0.10	0.04	2.31*	Base	0.19	0.05	3.49**
Gender	0.05	0.05	−0.92	Gender	−0.12	0.07	1.88
Grade 10				Δbeginning-end 10th			
Base	−0.08	0.04	2.04*	Base	0.16	0.05	−3.29**
Gender	−0.04	0.05	0.84	Gender	−0.02	0.06	0.31
Grade 11				Δbeginning-end 11th			
Base	−0.05	0.06	0.85	Base	0.24	0.07	−3.30**
Gender	0.08	0.07	−1.16	Gender	−0.21	0.09	2.37*

Estimation of between-class variance

	df	χ^2
Intercept	1,154	17,555.06

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

Discussion

The purpose of the present longitudinal study was to examine high-school students' motivation in mathematics over time, particularly in terms of competence beliefs, utility value and achievement goals, and thereby to provide a clearer picture of this evolution related to gender.

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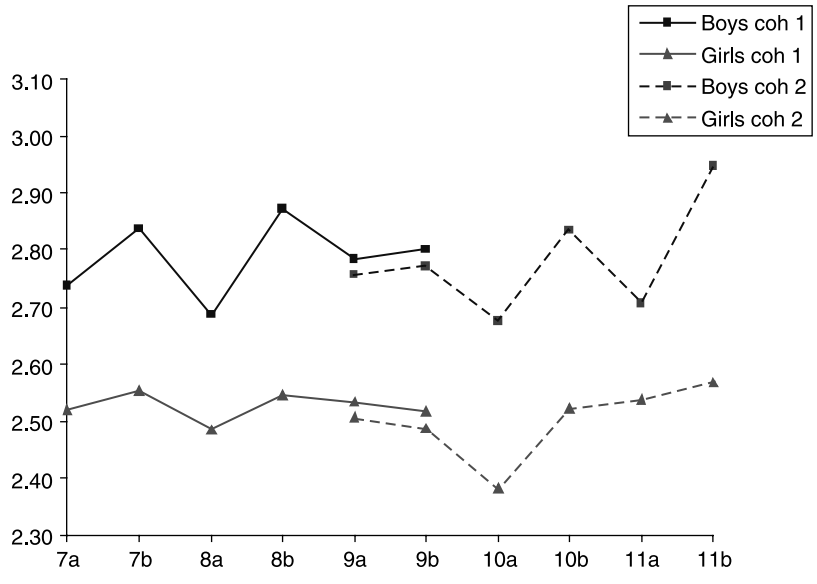


Figure 5. Changes of work-avoidance goals.

As expected, the present study reveals that motivation in mathematics declined as students grew older. Most studies reporting a similar finding in the past have focused on younger children (Eccles *et al.*, 1985; Ma & Cartwright, 2003; Stipek, 1993). However, some researchers have recently reported that the process of the gradual drop in achievement motivation continues in high school (Fredericks & Eccles, 2002; Jacobs *et al.*, 2002; Watt, 2004). Our own results support these findings. In the present study, except for girls' competence beliefs and performance-approach goals which remained stable throughout the study, there was a negative time effect on most variables over the period considered.

Prior researches lead us to expect that boys would have higher competence beliefs than girls in mathematics. Our results show this to be true at the beginning of secondary school but not by the end of it, due to a pronounced reduction in boys' competence beliefs over time. Thus, our results show that boys' perceptions of having the capacity to succeed and produce appropriate responses that may lead to success in mathematics diminish over time. This result is somewhat in line with the findings of Fredericks and Eccles (2002) who also found differential rates of decline in boys' and girls' competence beliefs in mathematics and, as a result, that the two genders had similar beliefs about their mathematics ability in high school. Nevertheless, our own results indicate that girls' competence beliefs remained stable throughout secondary school which is contrary with the results of other studies that found stability in boys' competence beliefs (Watt, 2004).

Our results confirm a steady decrease of high-school students' perception of the utility value of mathematics. They also indicate that this decrease was more pronounced for boys than for girls from grade 11. Fredericks and Eccles (2002) have found no significant differences between boys' and girls' perception of the importance of mathematics (a variable similar to utility value) and documented a decline of this perception over time, but with a slowing down in the rate of decline in secondary school and a slight increase at the beginning of grade 10. Watt (2004) has also found that

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boys and girls have similar results on utility value of mathematics, but observed that this perception declined through secondary school, with the extent of decline becoming greater over time (Watt, 2004).

A similar pattern of the gradual drop in the attitudes towards the learning of mathematics over time also emerged from our results on mastery-approach goals which declined through high school. This is in contradiction with the results of other studies (Middleton *et al.*, 2004; Skaalvik, 1997), probably because these authors limited their scrutiny of the transformation of mastery-approach goals in mathematics to middle school. Our own result is not that surprising, considering that most scholars suggest that competence beliefs, utility value and mastery-approach goals are closely related (Greene *et al.*, 1999; Jacobs *et al.*, 2002; Middleton *et al.*, 2004). Otherwise, performance-approach goals and work-avoidance goals remained moderately stable across grade levels, which is in line with the results of other studies. Interestingly, girls reported higher mastery goals than boys, who obtained higher performance-approach and work-avoidance goals. This partially confirms the findings of other who all obtained higher mean levels of performance-approach goals for boys in mathematics but no significant differences between boys' and girls' mastery goals (Anderman & Midgley,1997; Kaplan & Midgley, 1997; Seegers & Boekaerts, 1996).

A variety of explanations of the gradual drop in motivation in mathematics have been proposed. It is tempting to say that the concepts taught in mathematics classes become more difficult from one grade level to another, and that it may explain the decline of competence beliefs. However, there is little evidence to support that assumption (Anderman & Midgley, 1997). Moreover, the assumption is sometimes made that the decline of motivation in mathematics, as in other academic domains, is related to physiological changes associated with puberty and maturation and that they are inevitable. Some authors challenged that assumption, and proposed that classroom environment may be related to a reduction in students' motivation in mathematics: a greater number of students per class; a more authority-oriented approach to classroom management; higher teacher–student ratios; teaching by level of competence and in collective format; a greater focus on formal evaluation, grades, rank and social comparison; qualitative and quantitative reduction of contacts with teachers; and a deterioration in school-family relations (Eccles *et al.*, 1985, Harter, 1992; Wigfield & Eccles, 1994). However, these are speculations and more research is needed to identify the source of the decline of motivation in mathematics.

A number of differences between girls' and boys' motivation in mathematics were noted in the present study. Girls showed lower competence beliefs at the outset of high school, which tends to confirm other studies' results that reported that girls are affected by strong stereotypes of mathematics, the latter being identified as a male domain (Leder, 1986; Meece & Courtney, 1992). Nevertheless, most of the gendered differences observed in our study favour girls. In fact, girls reported no decline in competence beliefs, less decrease in utility value, higher mastery-approach goals and lower work-avoidance goals. Moreover, girls reported less decrease in performance-approach goals between the beginning and the end of academic years and less increase in performance-avoidance goals. However, boys maintained higher performance-approach goals. Overall, the findings of the present study do not bolster the hypothesis that girls are particularly affected by the general decline of attitudes known to be helpful in mathematics. In fact, the present findings suggest that boys experience a greater decrease over time in motivation in mathematics. Moreover, older girls show a more positive attitude towards mathematics than older boys. This is contrary to the findings of

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studies which concluded that the decrease in positive attitudes towards mathematics affects girls more than boys (Eccles *et al.*, 1985; Fennema & Sherman, 1977; Stodolsky, 1985; Watt, 2004) but is in line with the results obtained by others who have underlined that the gap between boys and girls decreased over time and proposed gender convergence rather than gender differentiation during high-school years (Jacobs *et al.*, 2002).

Finally, the finding that the scores on all variables were lower at the end of the academic year than at the beginning is another interesting finding of the present study. Most variables demonstrate non-linear fluctuations throughout the duration of the study; that is, they display a decline between the beginning and the end of the same academic year, yet tending to increase again at the beginning of the following academic year and some dropping even further at the end of that year. This last result indicates that the gradual drop in motivation in mathematics appears to be a two-step phenomenon: a decrease between and within grade levels. It also suggests that studies on the evolution of motivation should take into account the time of the academic year when measurement is done. Furthermore, practitioners should be aware that end of year grades are collected at the moment where students' motivation is at the lowest.

Our findings also have important practical implications. As underlined by many authors (Ames, 1992; Brophy, 2005 for example), teachers should avoid inciting competition among their students and should instead foster competence beliefs, utility value and mastery-approach goals. Indeed, specialists have emphasized that certain teaching practices tend to help convey high expectations to students: presenting tasks as realistic challenges, increasing help rather than diminishing the relative difficulty of tasks, questioning in a stimulating way, teaching efficient learning strategies and promoting strategic effort (Ames, 1992; Good & Brophy, 1995). Other teaching practices are known to exert positive effects on the goals and value students attribute to tasks and school subjects: making sure that the students are well aware of the content to be learned and the competence to develop, making them understand the meaning of what is learned, proposing stimulating tasks, offering options in content and courses and helping students to establish goals for themselves (Ames, 1992; Good & Brophy, 1995).

In conclusion, if our results support the hypothesis of a decline in motivation in mathematics during high school, they support neither the hypothesis of a slowing down of the decrease nor a recovery by the end of high school. In fact, at least in the case of utility value and mastery-approach goals, the decrease of motivation was more pronounced between the grades 9 and 11 than between the grades 7 and 9. This suggests that there is no recovery at all but the problem becomes even worse. This result could be explained in part by the fact that, in our sample, participants have no choice of complementary mathematics courses, unlike students in other studies. In Quebec, students follow the same mathematics courses until grade 11; they are then separated in strong or weaker tracks on the basis of their academic results in grade 10. Thus, many participants in the present study received negative judgment on their competence in mathematics and were oriented in academic programmes in which mathematics have a minor importance. This could possibly explain the accentuated decline of utility value and mastery-approach goals observed in grade 11. Moreover, our results support the theory of gender convergence in mathematics rather than gender differentiation. Finally, the gradual drop in motivation in mathematics appears to be a two-step phenomenon: a decrease between and within grade levels.

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Contribution and limits

In summary, the present study brings a significant contribution to the knowledge on the evolution of mathematics motivation during high school. Firstly, the use of a longitudinal research scheme, the utilization of a large sample, representative of the high-school population, and the use of a statistical robust procedure all contribute to the confirmation that mathematics motivation gradually falls during high school. Moreover, to our knowledge, only a few studies have examined the evolution of achievement goals in mathematics across middle and high schools. Our results also bring support to those who claim that the change in achievement motivation now affects more boys than girls. Finally, our results bring a new light on this question, revealing that the gradual drop in achievement motivation is a double phenomenon which is manifested between and within grade levels.

The main limitation of our study stems from the fact that only one domain was considered and this limits the possibility of generalization. It would be beneficial for future research to explore various disciplines using a similar research design. It could also prove fruitful to carry out year-long data collection in order to pinpoint the time of year when decline in the motivation occurs, and to discern how such changes might be related to achievement. Another limitation of the present study is that mastery and performance avoidance goals were not measured. Further studies should include these achievement goals and help clarify the relevance of the multiple goals theory. Moreover, the use of a self-reported questionnaire should be a complement with other data gathering techniques like observation and interview.

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