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GENDER DIFFERENCES IN THE CAUSAL RELATION BETWEEN ADOLESCENTS' MATHS SELF-CONCEPT AND SCHOLASTIC PERFORMANCE

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Mathematics is a core subject in every school curriculum and it is strongly correlated with maths self-concept, which is defined as the subjective feelings and beliefs about one's competence in maths. In general, boys tend to report higher maths self-concept than girls, but the difference between boys and girls' maths scholastic performance is low or even inexistent. Some authors maintain that academic self-concept can play an important role as a motivational variable, promoting self-confidence and investment in the learning process. This study examined the causal relations between maths self-concept and maths scholastic performance in four cohorts of boys and girls within a three-wave longitudinal study. The first two cohorts were composed of 187 girls and 139 boys attending grades 7 and 8 at Time 1 and the third and fourth cohorts were composed of 167 girls and 123 boys attending grades 9 and 10 at Time 1. Structural Equation Modelling was used to test the fit of several models of causal relations. The results revealed that for the first two cohorts the best models were reciprocal and skill-development for both boys and girls. However, for the older students, a reciprocal model gave a best fit for the boys, but for the girls there was only one significant effect from maths self-concept to maths scholastic performance. Results are discussed on the basis of gender-related differential learning expectancies.

Introduction

Maths is a core subject in every school curriculum and performance in maths is strongly correlated with maths self-concept, which is defined as the subjective feelings and beliefs about one's competence in maths (Marsh, 1989). The expectancy-value model of Eccles and collaborators (Eccles (Parsons), Adler, Futterman, Goff, Karczala et al., 1983; see also Eccles & Wigfield, 1995, 2002; Eccles, Wigfield, & Schiefele, 1998) posits that beliefs

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about academic ability and achievement are influenced by past performances, the perceived task difficulties, and contextual factors, including socializing information and support provided by significant others. Maths has been identified as a critical domain that gives access to many high-status, high-income careers (Watt, 2005). The reasons why girls and young women often choose to discontinue their studies and careers in maths-related domains, as they progress to higher educational and professional levels, seem to be an international concern (Herzig, 2004).

In general, boys tend to reveal higher maths self-concepts than girls (Dermitzaki & Efklides, 2001; Eccles, Jacobs, & Harold, 1990; Harter, 1985; Marsh, 1989, 1994; Marsh & Yeung, 1998; Skaalvik, 1990), even when the differences between boys' and girls' maths scholastic performance are low or inexistent (Dermitzaki & Efklides, 2001; Hyde & McKinley, 1997; Marsh & Yeung, 1998; Skaalvik, 1990). Indeed, the latest research outcomes and reviews have shown very few gender differences in maths aptitude or even maths scholastic performance (Halpern, 2000, 2004; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Linver & Davis-Kean, 2005; Watt, 2005). Dermitzaki and Efklides (2001) analysed maths scholastic performance, maths self-concepts and metacognitive experiences of 7th, 9th and 11th graders, and found that although gender did not differentiate maths performance, it did affect maths self-concept (higher for boys) and metacognitive experiences. Jacobs et al. (2002) found that maths self-concept declined for both boys and girls, between grades 1 and 12. However, they also found that boys' maths self-concept declined faster and that 12th grade girls valued maths more than boys.

Although self-concept is not as popular as other self related variables in the learning motivation research field, some authors assume that academic self-concept can play an important role as a motivational variable (Byrne, 1984; Covington, 1984, 1992, 2001; Fontaine, 1999; Zimmerman, Copeland, Shope, & Dielman, 1997), promoting self-confidence and investment in the learning process. Motivation to achieve is conceptualised as a subjective disposition oriented to promote or to maintain a high level of accomplishment (evaluated through specific patterns of excellence) which develops through experience (Fontaine, 1999); it is not treated either as a global stable trait or as an exclusively context derived characteristic. When faced with achievement tasks, some students behave in a more motivated way, with more investment, effort, and persistence, while others avoid the most challenging situations. The former usually reveal higher standards of achievement. To understand those differences, research has placed emphasis on the cognitive and affective dimensions of the self, within a paradigm defined as *person-process-context* (Fontaine, 1999), since perception of reality depends not only on the context itself, but also on the previous experiences of the individuals and on their personal interpretation of those experiences. Perception of personal ability to cope with situational demands is at the core of these processes.

Accordingly, several theories in the achievement motivation domain, have tried to relate several self-perceptions to academic achievement or scholastic performance. Among them, the attribution theory for success and failure (Weiner, 1980), the self-efficacy theory (Bandura, 1977, 2001), the self-esteem theory (Covington, 1984, 2001) and the expectancy-value theory of motivation (Eccles (Parsons) et al., 1983) have each stressed the motivational role of self perceptions. In general, research within these theories is based on the assumption that subjective perceptions of academic success and failure experiences shape individuals' academic self-concept (as well as self-efficacy and other self-perceptions), which in turn influences their behaviour, persistence and academic choices, and they are as important as the individual cognitive ability, goals and previous academic or scholastic performance (Fontaine, 1999).

According to Wylie (1979) many people and especially educators, have assumed without hesitation that academic success and/or much of the students' perceptions of competence are strongly related with own competence, as well as with global self-esteem. Thus, as Hattie (2000, p. 42) acknowledged, "self-concept is not just a desirable object in itself, but a mediator of other desirable outcomes and this assumption has important implications in education". So, most of the interest in the study of the relationship between academic self-concept and scholastic performance comes from the assumption that modifications in the former variable will drive modifications in the latter, through the modification of the levels of motivation for success (Byrne, 1984).

In a critical review of several studies which have examined the relations between academic self-concept and scholastic performance, Byrne (1996) has specified several important features to be included in the research design, if consistency of the results is to be ensured. On one hand, Byrne stressed the importance of the use of empirically validated multidimensional instruments to assess academic self-concept, based on the model initially proposed by Shavelson, Hubner, and Stanton (1976) and Marsh and Shavelson (1985). This multidimensional model of self-concept has been empirically validated by Byrne, Marsh and other researchers (Byrne & Gavin, 1996; Byrne & Shavelson, 1986, 1988; Marsh, 1987, 1990c, 1990e, 1993; Marsh, Byrne, & Shavelson, 1988; Marsh & Hocevar, 1985). On the other hand, Byrne (1996) also argued that scholastic performances need to be assessed in the specific school subjects related to the academic self-concept dimension under study. Scholastic performance is more strongly correlated with academic self-concept when its specific dimensions are assessed and the performance measures are obtained in the related school subjects (Byrne & Shavelson, 1986; Fontaine, 1991a, 1991b; Marsh, 1984, 1992; Marsh, Byrne et al., 1988; Marsh, Parker, & Barnes, 1985; Marsh, Parker, & Smith, 1983).

Although the correlation between academic self-concept and scholastic performance is no longer questioned, interpretation of the results still diverge about the direction of the causal relations between these variables. Three models of causal direction have been proposed. The first one, the *self-enhancement model*, claims that self-concept directly influences scholastic performance and accordingly, psychological interventions should be designed primarily to enhance academic self-concept (Covington, 1984, 2001; Zimmerman et al., 1997). The second model, the *skill-development model*, claims that academic self-concept is regulated mainly by and through previous experiences of success and failure and through the feedback of educators; in itself it is not a pre-condition for success. The empirical results that have evidenced a progressive realism with age in the students' subjective evaluations of their academic competencies help to sustain this model of causality (Byrne, 1986; Eccles, Wigfield, Flanagan, Miller, Reuman, & Yee, 1989) The third model, the *reciprocal model*, proposes a more dynamic and integrated view of the causal relations between scholastic performance and academic self-concept and adds that reciprocal effects are more likely to occur, if certain moderator or mediator variables are operative. The early work of Marsh (1984) on the relationship among these variables suggested that scholastic performance, academic self-concept and cognitive attributions for success and failure should interact in a constantly balanced complex network of reciprocal relationships and that changes in any of the variables should produce changes in the others.

Thus, the analysis of the causal predominance between academic self-concept and scholastic performance continues to be important, and according to the outcomes, psychological interventions have to be planned to promote academic competence or self-concept or even both, depending on context variables. However, research has revealed quite different and sometimes even contradictory outcomes. These apparent contradictions, according to Marsh (1990a; Marsh, Byrne, & Yeung, 1999) may be mainly explained by the methodological choices of different researchers. According to Marsh and Yeung (1997) the studies addressing the causal relations between scholastic performance and academic self-concept should take into consideration several factors: (a) constructs should be assessed at least twice on the same samples, but preferably more than twice; (b) both constructs – academic self-concept and scholastic performance – should be treated as latent variables, inferred through multiple indicators or observed variables; (c) the size of the samples should be large enough to allow the use of structural equation modelling (*SEM*); and (d) the models used to test causal relations should begin with a *full-forward reciprocal model* allowing each of the correlations between each of the observed variables at all the times of assessment (*correlated uniqueness*) to have the possibility of inferable influence.

Research results may not be consistent, not only because they do not observe the same comprehensive methodological guidelines proposed by Marsh and Yeung (1997), but also because the causal relations themselves may in fact vary with the age/grade of the participants or with other context variables, such as gender or socio-economic status.

In the Marsh and Yeung (1997) study, the causal relationships between scholastic performance and academic self-concept were assessed for three school subjects: maths, language (English), and science, in a sample of 600 boys, attending grades 7 to 10 at the first point of assessment. Scholastic performance was assessed by the students' grades on six occasions, obtained at the beginning of the first and second semesters in each of the three years of the longitudinal study, and from teacher feedback in maths, English and science. The academic self-concept in the referred domains was assessed at the beginning of the second semester in each of the three years, using Marsh's Academic Self Description Questionnaire. In the first place, this study confirmed that the models that best fitted the data were those in which variables were inferred from more than one indicator, and in which correlated uniqueness was allowed. Marsh and Yeung (1997) further concluded that for each of the academic self-concept dimension considered (maths, science or English), the best models were the reciprocal ones. Nevertheless, after controlling for previous scholastic performances, they also demonstrated the significance of previous academic self-concept on later performance, thereby supporting the self-enhancement model. However, these effects were found when the dimensions of academic self-concept were assessed at the beginning of the second semester and the scholastic performance was observed at the end of the same year. Besides that, Marsh and Yeung (1997) also found that these effects were somewhat stronger in maths than in English and science. This study made it feasible to conclude that the particular dimension of academic self-concept under assessment can determine, at least, the magnitude of the causal effects found.

Causal predominance has also been found to vary with the age or grade level of participants. It is probable that the feedback from teachers and from marks plays a greater role in the regulation of academic self-concepts for younger than for the older ones (Helmke & van Aken, 1995; Hoge, Smith, & Crist, 1995; Skaalvik & Hagtvet, 1990; Wigfield & Karpathian, 1991). With age, students do not regulate their academic self-concepts exclusively through the external feedback they get from teachers and marks (reflected appraisals), but also from more internal criteria (internal appraisals). In this way, reciprocal effects or even self-enhancement effects between academic self-concept and scholastic performance can be expected at a later age or grade level (Guay, Marsh, & Boiven, 2003; Helmke & van Aken, 1995; Peixoto & Miguel, 2002; Skaalvik & Hagtvet, 1990).

In a two-wave three-variable panel study, Skaalvik and Valas (1999) examined the causal predominance between academic self-concept and scholastic performance, separately, for maths and language, in about 1000 participants who were in grades 3, 6 or 8 (mean ages of 10, 13 and 15 years) at the first moment of assessment, and then again one year later. The results revealed effects of maths and language performance on later academic self-concepts in all cohorts and in both domains, supporting the skill-development model.

Hoge et al. (1995) assessed 322 students at the beginning and end of grade 6 and at the beginning and end of grade 7 (four observations). Scholastic performance was assessed from the final marks in maths, English, social sciences and natural sciences. Academic self-concept was also assessed in each one of these four school subjects. The results revealed causal effects only within each of the two school years (from time 1 to time 2 and from time 3 to time 4), and reciprocal models of causal influence were obtained for every self-concept dimension. Nevertheless, the authors concluded that the results supported the skill-development model, since the effects of scholastic performance on later academic self-concept were always stronger than the effects of the latter on the former. However, as in the Skaalvik and Valas' (1999) study, the stability indices within the variable scholastic performance were quite high (mean r = .94) which could, in the authors' opinion, have affected the magnitude of the cross-lagged effects.

The results of Helmke and van Aken (1995) allowed to infer a causal relation between maths self-concept and maths scholastic performance on 697 students in 54 German schools, attending grade levels 2 and 4. Maths performance was assessed through standardised tests and marks. They also found the skill-development model to be consistent with the correlations between the variables from grade 2 to grade 3, but a reciprocal model from grade 3 to grade 4. They did not find any differences in global fit indices between the models using scholastic performance and standardised tests, either separately or together. However, when the two indicators were used together in the same model, the paths from scholastic performance to self-concept were stronger. These authors suggested that the self-enhancement model was not clearly supported in their study, probably because at these ages, the motivational properties of academic self-concept may not yet be observable. Helmke and van Aken did not find any gender differences in their study, but Fontaine (1995) did observe such differences in a two-wave longitudinal study.

Fontaine (1995) assessed 236 Portuguese students attending grades 5, 7 and 9 and two years later. The *SEM* revealed that for the total sample, for low and middle/high socio-economic status groups and for the girls, the scholastic performance overall influenced later global academic self-concept – supporting the skill-development model – but for boys, the reciprocal model was a better fit. Fontaine explained the results by referring to the differential learning expectations of the two genders in the Portuguese learning environment. Although girls in fact perform better than boys scholastically, they still view themselves as less intelligent and so they need the repeated feedback of high marks to validate their perceptions of competence, which is not the case for boys. Contrarily to Fontaine (1995), Marsh and Yeung (1998) found gender invariance in the effects of maths and English self-concept on latter maths and English marks, but they studied only 8th graders, in a three-wave longitudinal study, and used English and maths constructs in the same model. Marsh and Yeung (1998) concluded that self-concept influenced latter school marks and test scores, and coursework selection, even after controlling for the effects of prior school marks and test scores, supporting the self-enhancement model for maths and English self-concepts.

More recently, Guay et al. (2003) investigated three cohorts of students (grades 2, 3 and 4), assessing both scholastic performance and self-concept at reading, writing and maths. Measures were obtained three times over one year. The authors used teacher ratings instead of standardised tests to infer scholastic performance, since they considered that at these ages self-concept is much more dependent on the social processes of comparison than on real abilities. The results supported a reciprocal model for all three cohorts from time 1 to time 2 but a self-enhancement model from time 2 to time 3. Comparing their results with Skaalvik and Hagtvet's (1990), Guay et al. (2003) concluded that the skill-development model found by the first researchers was due to the fact that students received feedback from marks only after they were at 7th grade, while in their own study, students had access to their grade marks from the beginning. Guay et al. (2003) also concluded, from a developmental perspective, that the older children's higher cognitive abilities allow them; (a) to improve the coordination between their different self-representations, leading to a greater correspondence between self-concept and evidence from external criteria; (b) to use social comparison processes, which in turn allows a more balanced self image, and (c) to internalise the evaluative external criteria, which allows them to have less egocentrically dominated self-evaluations. Although they concluded that older children have more realistic self-concepts of competence (more based on external criteria), these authors also acknowledged that their results supported the need for psychological interventions based on both self-enhancement and development of learning skills.

The research on the relations between academic self-concept and scholastic performance is still important precisely because the relevant facts and the most likely explanations should determine in which contexts psychological and educational interventions should be based primarily on self-concept enhancement, on skill development or on both together. Indeed, the results reported have revealed some apparent inconsistencies because, although all the studies used longitudinal designs and structural equation modeling to test the causal prevalence between the two variables, the samples have not been comparable across the different studies, especially in respect of age and school experience. Thus, it is possible that grade level, gender, the self-concept dimension or even the school subject under consideration are differentially relevant to the direction of causality.

This study aimed to observe the likely causal relations between maths self-concept and maths scholastic performance differentially, in four age cohorts of boys and girls observed annually over three years. It is possible that the relations between maths self-concept and maths scholastic performance are the result of different psychological processes in boys and girls, as already implied by earlier studies.

Method

Participants and procedure

The participants were students from six secondary schools. In each school the students answered the questionnaires at the beginning of the first term (September) in three successive years (2001, 2002, and 2003). Only the students that answered all items at the three times of assessment were kept in the sample. The final sample was composed of four cohorts of students; cohort 1: 181 students (80 boys and 101 girls) attending grade 7 in the first year of assessment; cohort 2: 145 students (59 boys and 86 girls) attending grade 8 in the first year; cohort 3: 146 students (63 boys and 83 girls) attending grade 9 in the first year, and cohort 4: 144 students (60 boys and 84 girls) attending grade 10 in the first year.

Since the structural equation modelling (*SEM*) requires large samples to work, and as the aim of the study was to compare gender groups, the models of causal relations were tested joining the first and second cohorts, as well as the third and fourth. In this way, cohorts 1 and 2, on one side, and cohorts 3 and 4 on the other were put together in the first place and then divided into four new cohorts, according to gender; cohort A, composed of girls that attended grades 7 and 8 on time 1 (first year of assessment); cohort B composed of boys of the same grades; cohort C composed of girls who attended grades 9 and 10 at the first year of observation and finally cohort D, composed of boys of the same grades.

Instruments

To assess maths self-concept, the Portuguese version of Self-Description Questionnaire (SDQ-II) (Fontaine, 1991a), originally developed by Marsh (1990b) was used. It comprises 10 items, five of each negatively worded, with six possibilities of answering on a *Likert type* scale ranging from "totally agree" to "totally disagree". Examples of the items are: "Maths is one of my best subjects"; "I never got good marks in maths"; "I have always done well in maths"; "Frequently I need help in maths". The reliability of SDQ-II (*Cronbach's alpha*) ranged from α = .93 to α = .95 (Table 1).

Table 1.
Cronbach alpha values for maths self-concept in each cohort and time of assessment.

	items	Time 1	Time 2	Time 3
Cohort A; girls (n = 187)	10	.93	.94	.93
Cohort B; boys (n = 139)	10	.94	.93	.93
Cohort C; girls (n = 167)	10	.93	.94	.94
Cohort D; boys (n = 123)	10	.93	.95	.94

Maths scholastic performance was inferred from the self-reported maths marks of the last term of the previous school year. Self-reported marks are often used to infer scholastic performance when the access to secondary school students' file is difficult or denied, as was the case for this research. Students were asked to report their actual marks from the previous year in all school subjects, and not how good they thought they were at those school subjects. Memory problems are minimised as the time between the final evaluation of the previous school year and data gathering was not long, and data was always gathered at the beginning of the school year (with the summer holidays in between). Moreover, the final marks of each school grade, before the summer holidays, are quite salient as they define whether or not the student passes on to the next grade level. Social desirability bias in self-reported marks was reduced through the guarantee of confidentiality of all gathered data. Finally, in order to avoid the influence of self reported marks on self-concept, students reported them, in all school subjects, after self-concept assessment.

All marks were computed into a 0 to 100 scale, since in grades 7 to 9, the marks' scale ranges from 1 to 5 (the best) and in grades 10 to 12 it ranges from 1 to 20 (the best). Maths self-concept scores were also computed into a scale ranging from 0 to 100. Mean and standard deviation values of maths self-concept and maths marks are presented on table 2.

Table 2.
Mean (M) and standard deviation (SD) values for maths self-concept and maths marks in each time of assessment for the four cohorts of participants.

	Time 1		Time 2		Time 3	
	M	SD	M	SD	M	SD
Cohort A, girls (n = 187)						
Maths self-concept	57.60	27.72	53.85	28.21	52.46	28.10
Maths marks	63.66	18.16	64.07	18.30	61.38	17.87
Cohort B, boys (n = 139)						
Maths self-concept	64.07	27.15	60.32	29.21	55.54	28.45
Maths marks	65.44	20.43	65.67	20.90	60.73	18.69
Cohort C, girls (n = 167)						
Maths self-concept	54.69	25.23	53.88	28.73	47.33	27.07
Maths marks	67.65	20.34	65.03	19.82	56.20	15.37
Cohort D, boys (n =123)						
Maths self-concept	58.21	24.33	55.23	29.45	49.56	27.82
Maths marks	68.44	21.84	66.49	21.08	58.24	17.25

Results

The analysis of the causal relationships between maths self-concept and maths scholastic performance was carried out through the method of *SEM*, using the AMOS (Analysis of Moment Structures) program (Arbuckle, 1997) to estimate the parameters, based on the maximum likelihood procedure.

The *SEM* is a multivariate technique that allows the testing of the causal relationships among latent variables (not directly observed) inferred from a group of observed variables. According to Byrne (1994), *SEM* is the best technique to analyse the causal relations among variables in longitudinal design studies and it has some advantages over other multivariate techniques, such as; taking into consideration the variance instability over time and allowing simultaneous estimation of the measurement error, the statistical significance of each causal effect and the global adjustment of the hypothetical model. If the global adjustment of the tested model is suitable, the likelihood of the relationships or effects described by the model is accepted.

The global adjustment of the models was observed through several fit indices (table 5); the TLI ("Tucker-Lewis coefficient") developed by Tucker and Lewis (1973), the RMSEA ("root mean square error of approximation"), the CFI ("comparative fit index"), and the chi-square statistic. The TLI is considered one of the best global fit indexes, since it is independent of sample size and it penalises model complexity (Marsh, Balla, & MacDonald, 1988). Values over .90 (ranging between 0 and 1) indicate good fit. The RMSEA (Browne & Cudeck, 1993) is an index that does not penalise model complexity and tends to favour more complex models. By convention, the model fit is good enough if RMSEA is less than or equal to .05 or at least .08 (Steiger & Lind, 1980, cit. by Arbuckle, 1997). The CFI (Bentler, 1990; MacDonald & Marsh, 1990) compares the existing model fit with the "independence model", which assumes the latent variables in the model are uncorrelated. It ranges from 0 to 1. By convention, CFI should be equal to or greater than .90 to accept the model. Finally, the chi-square statistic is used as a "badness of fit" index. When the hypothetical model does not fit the data, the chi-square is significant. However, this statistic is sensitive to sample size and some authors suggest that when other global fit indices are good, the chi-square (χ^2), although significant, may be divided by the degrees of freedom. The ratio χ^2/df is considered an acceptable adjustment if it is below 5 (Giles, 2002), although this criterion is not always accepted by researchers. Marsh and Hocevar (1985) suggested that a ratio below 2 would be very good and between 2 to 5 would indicate an acceptable adjustment, while Byrne (1989) affirmed that ratios over 2 should not be accepted. Chi-square difference statistic is also used to measure the difference between two models of the same data, in which one model is a nested subset of the other. Finally, it is important to stress that the choice of the most suitable model depends not only on the global fit indexes but also on substantive and theoretical arguments, especially when more than one model reasonably explains data (Byrne, 1994; Fife-Schaw, 2000; Reise, Widaman, & Pugh, 1993).

The models tested for the causal relations were performed using three observed variables or indicators to infer the maths self-concept, a latent variable in the model (Figure 1), and one observed variable representing maths scholastic performance (maths marks).

The three observed variables used as measures of the maths self-concept were obtained adding items, following a usual procedure in *SEM*. Marsh and Yeung (1997) affirmed these additions of items yields a more normal distribution, a less idiosyncratic variation of the items and a higher reliability of the measurement model. It also reduces the number of parameters to estimate when testing the model. Following the recommendations of Marsh (1990a) a full-forward reciprocal model was initially tested (Figure 1) for each cohort, which means that as a first step, all cross-lagged effects between the two variables from one time to the other were estimated. All the correlated uniqueness was also estimated, that is, the correlation between all measurement errors associated with the three indicators of maths self-concept from time 1 to time 2 and from time 2 to time 3. Indeed, when several measures are repeated several times, it is expected that the errors associated with measures

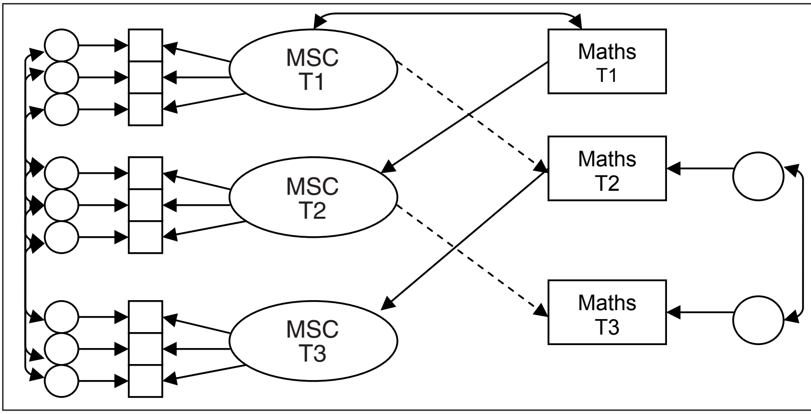

Figure 1.
Structural equation models tested for the causal relation between maths self-concept and maths marks. MSC = maths self-concept; Maths = maths marks or maths scholastic performance; T1 = time 1; T2 = time 2; T3 = time 3. Square boxes correspond to observed variables; circles correspond to error-variance associated to observed variables; ellipses correspond to latent variables.

will be correlated and so these correlations must be included in the models (Marsh & Hau,1996).

The next step was to test successive models (nested models), removing the non-significant effects or paths one by one and comparing the global fit indices of each model to the previous one. This kind of procedure, usually called model-trimming, consists of deleting one path at a time. The aim is to find the most parsimonious model that fits the data. In some cases, the other indices of global model fit for the more parsimonious model may justify its retention in spite of a significant chi-square difference test.

The final causal models obtained for each cohort are presented in Figure 2.

In cohorts A and B, causal effects of scholastic performance on maths self-concept are revealed for both genders, from time 1 to time 2 and from time 2 to time 3. The effects of maths self-concept on maths scholastic performance from time 1 to time 2 also appeared. In these cohorts, a reciprocal and a skill-development model explains the causal relations between the variables for both genders.

However, in cohorts C and D, while for girls the model that best represents the causal relations between maths scholastic performance and self-concept is the self-enhancement model, for the boys the reciprocal model is better, as it was for the Cohort B (younger boys). From time 2 to time 3, no significant paths or effects were observed between the variables in cohorts C and D.

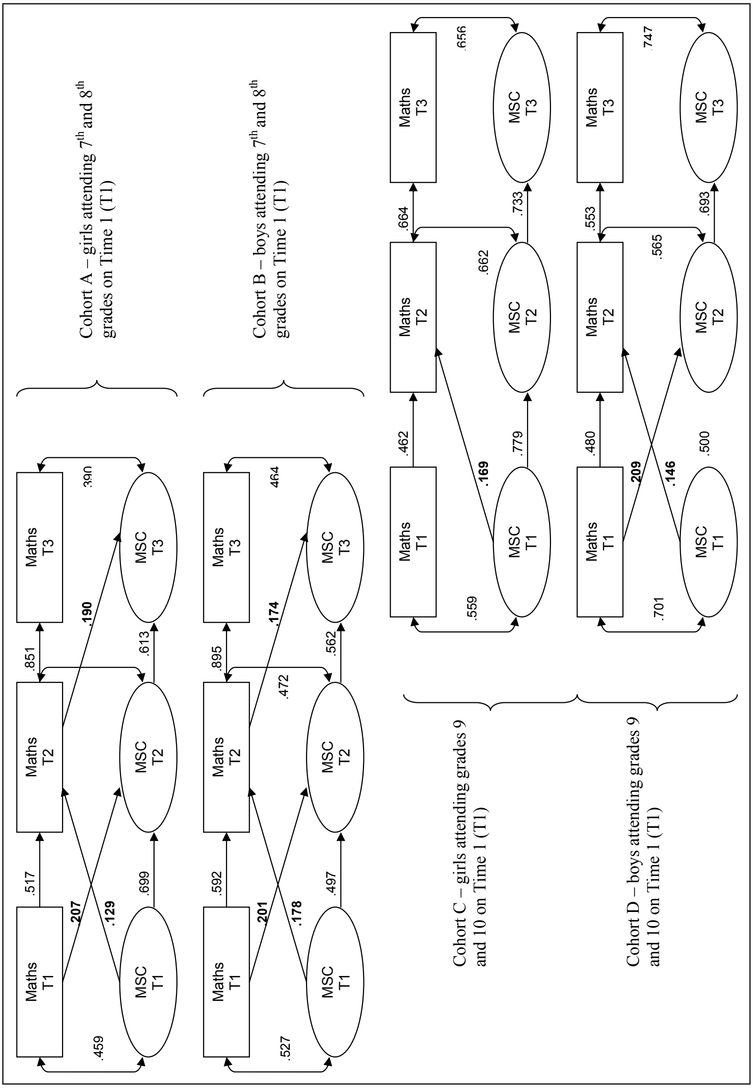

Figure 2.
Structural equation models that explain data in the causal relation between Maths grade marks (Maths) and Maths academic self-concept (MSC) according to gender and grade level.

Table 3.
Global fit indices obtained for the final models in each cohort.

	Global fit indices				
	$\underline{X}^2$ (df)	$\underline{X}^2$ / df	CFI	TLI	RMSEA
Cohort A	2278.734 (66) [a]				
Girls	65.451 (40)	1.64	.988	.981	.058
Cohort B	1769.342 (66) [a]				
Boys	77.626 (40)	1.94	.978	.964	.080
Cohort C	2230.781 (66) [a]				
Girls	101.132 (42)	2.41	.973	.957	.085
Cohort D	1442.419 (66) [a]				
Boys	48.475 (42)	1.15	.995	.993	.036

[a] = independence model

Discussion

Observing the results of this investigation, it seems undeniable that maths scholastic performance does have an influence on maths self-concept during secondary school, but that the opposite directional influence may also occur, as has been observed in other research work (Fontaine, 1995; Marsh, 1990a; Marsh & Yeung, 1997, 1998; Skaalvik & Hagtvet, 1990). If it is accepted that adolescents' academic self-concept is regulated through the objective feedback of marks, it is also possible to affirm that a high self-concept can work as an adaptive cognition and affective state which boosts the effort and persistence to achieve in school. This is the case in school maths for Portuguese students, following the results of this research, at least in 7th/8th and 9th/10th grades. In the Portuguese school system, grades 7 and 10 are the beginning of different academic cycles, progressively more demanding and frequently associated with school change, new teachers and classmates. The motivational role of self-concept seems to be aroused when students need to cope with these social or environmental changes. In the framework of Dweck's goal orientation theory, students' confidence in their own capacity to deal with environmental challenges is associated with learning goals and confidence in their own skills and competencies more than with performance goals and competitiveness. Such self-confidence can promote openness to experience and interest in task-solving processes leading to an easier adaptation to new contexts and improving performance levels (Dweck, 1999). Indeed, the motivational role of self-concept that was observed in this study emerged after changes in academic context: influence of maths self-concept on scholastic performance has been observed for 7th and 9th/10th graders.

Some differences between boys and girls were also observed in the causal models. For the girls in grades 9 and 10, the maths self-concept influenced later maths scholastic performance and no effect of performance was observed on later self-concept. For the boys of the same age, the reciprocal model described the relation between the variables better, as it did in earlier grade levels (7th/8th grades). Recent research has not found differences in maths scholastic performance or even maths ability between boys and girls (Dermitzaki & Efklides, 2001; Hyde & McKinley, 1997; Jacobs et al., 2002; Linver & Davis-Kean, 2005; Marsh & Yeung, 1998; Watt, 2005), especially in later grade levels, showing that as girls proceed in secondary school education, they seem to benefit from "maths exposure", reducing the maths gender gap (Halpern, 2000, 2004; Hyde & McKinley, 1997). In order to explain the pervasive gender differences in academic self-concept development, Marsh and his colleagues (Marsh, 1990f; Marsh, Kong, & Hau, 2001; Marsh & Yeung, 1998) have proposed an *internal-external frame of reference* model. The *external framework* model is based on performance comparison among students for each school subject; students with higher scholastic performance feel more competent than those with lower performance. This external comparison process cannot explain gender differences in maths self-concept in the later grades, since no differences in performance are observed. Another process of comparison, a more intra-individual one, needs to be considered. The *internal framework* model is based on internal comparisons. Students feel more competent in the school subjects they have better marks when comparing their own performances across different school subjects. Boys usually have higher maths self concept because their marks in maths are higher than their marks in language-related school subjects. Because girls get higher marks in language than in maths, they perceive themselves as less competent in maths. The effect of this ipsative-like process can possibly explain the often-observed gender differences in maths and language self-concepts. These differences converge with gender-typed socialisation which expect boys to be more skilled in maths and maths-related school subjects than girls, who in turn are expected to be more skilled and to have better scholastic performance in verbal reasoning (Eccles, 1987; Eccles, Barber, & Jozefowicz, 1999; Eccles et al., 1990, 1998). Besides that, maths scholastic performance is usually associated with cognitive ability or intelligence and is much more academically and socially valued than performance in other school subjects.

Self-concept development is also dependent on the feedback provided by significant others. Convergence between self-descriptions and descriptions by significant others is associated with well-being and efficacy in school (van Aken, van Lieshout, & Haselager, 1995). Some research outcomes have shown that girls may be more sensitive to others' expectations about their maths scholastic performance. In a longitudinal study between grades 9 and

11, Linver and Davis-Kean (2005) found that besides previous marks, the maths self-concept and maternal education and expectations were stronger predictors of the growth curve of maths achievement scores for maths high-ability girls than for boys of the same tracking group. For girls in the high-ability group, a higher maths self-concept was related to a less steep decline in marks over time, which was explained by the authors as a protective effect of maths self-concept against marks decline throughout secondary school. Dermitzaki and Efklides (2001) also found that three aspects of girls' maths self-concept (self-perception, self-esteem and self-efficacy) were influenced by others' perception of their own abilities, whereas in the case of boys only maths self-perception was influenced. The authors concluded that girls relied heavily on others' perception of themselves in order to judge their abilities, self-esteem, and self-efficacy in maths. Boys relied more on their own self-perception and, indirectly, on other's perceptions of them.

Another study, carried out in Israel by Birenbaum and Nasser (2006) revealed that Arab girls from a public school achieved higher maths performance than boys and perceived their parents' expectations for their success in this school subject as higher than did Arab boys. Still, for the girls, the teacher expectations were also good predictors of their maths marks while for boys these did not make any difference. Teachers' feedback seems to make boys' cognitive ability more evident than girls' when they have good maths marks. Teachers are less likely to attribute girls' scholastic performance to their abilities in this school subject, than they do for boys, and more frequently girls' achievement by appeals to attention, obedience or effort. While these same motives are used to explain boys' failure, lack of ability is evoked to justify girls' failure (Marshall & Weinstein, 1986). Such socialisation practices fail to adequately reinforce girls' maths self-concept.

Good marks are not enough to sustain girls' maths self concept at the same level as that of boys. Girls have to deal with less favourable stereotypes than boys and need to deal with teachers' practices which do not support their self-concept. However, our results show that this process may change with age. During adolescence, cognitive development allows students to use more complex self-justifications for their attitudes and behaviours in order to enhance their self-concept. As previous researches have shown (Linver & Davis-Kean, 2005; Watt, 2005), when girls feel more competent or self-confident in maths they will probably invest even more in this area, which will be against less favourable stereotypes or even unsupportive teachers' practices. As our results have shown, boys also need self-confidence in maths at the same stage (since maths self-concept influences later maths scholastic performance), but they keep regulating their maths self-concept through their previous maths scholastic performance, while girls seem to stop using this feedback to regulate their maths self-concept after grades 9/10.

Our results suggest that enhancing maths self-concept could be very helpful to adolescents with a social image of lower maths ability, especially if transmitted by social stereotypes and reinforced by socialisation practices. They need high self-concept to feel free to invest with confidence in maths and to persist against difficulties. This seems to be particularly important for girls. Confidence in own competence is also needed when students must adapt themselves to new academic contexts. For the boys, good scholastic performance may feed this confidence. Age and gender are thus moderating variables that influence the way maths self-concept interacts with maths scholastic performance. As these results are also dependent on social norms and values, contextually informed cross-cultural comparisons are needed to assess the influence of macro-systemic factors, once our results seem to contradict some previous ones (e.g., Marsh & Yeung, 1998). Such differential results are necessary to choose which kind of psychological interventions will best suit students' characteristics in their school context, i.e., whether promoting self-enhancement or skill-development.

This study has some limitations. It did not allow us to answer all the questions that remain about the causal relations between academic self-concept and scholastic performance. It is important to find out whether the results vary across school subjects; comparisons among school subjects are necessary to test for such differences. The language and maths self-concept dimensions, for example, show a different development in boys and girls, as has been reported in several research outcomes (Eccles et al., 1989, 1990; Fontaine, 1991a, 1991b, 1995). Moreover, the sample sizes did not allow for testing of the hypothetical models for each cohort separately; at different grade levels the models may be different, especially after grade 9. We also think that the motivational effects of maths self-concept on performance will possibly be more clarified if the causal effects are tested separately for each grade level, especially at grades 7 and 10, which are transition periods during secondary school. It would also be important to include other indicators to assess maths scholastic performance, such as standardised tests on maths reasoning, in order to improve the performance of structural equation models, testing causal relations with latent variables exclusively. Once the influence of girls' maths self-concept on maths performance has been observed at late adolescence, it is necessary to carry on research focussing on the determinants of this self-concept dimension, exploring the influence of social support from family and peers, mother and father expectations and levels of education, among others.

Finally, although we believe that, in this study, self-reported marks were reliable and valid measures of real marks, we cannot discount that the use of self-reported marks may increase the relation with academic self-concept. We used several checks to avoid memory and social desirability bias and self reported marks were obtained after self-concept assessment, to prevent the influence of the former variable on the latter. Nevertheless, whenever possible, it is preferable to use real marks to assess scholastic performance.

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Appendix

Table A1.
Correlations between maths self-concept and maths marks in cohorts A (above diagonal) and B (under diagonal).

	MSC T1	Maths T1	MSC T2	Maths T2	MSC T3	Maths T3
MSC T1	1	.438	.722	.518	.561	.433
Maths T1	.510	1	.432	.642	.424	.593
MSC T2	.568	.430	1	.621	.691	.479
Maths T2	.475	.665	.663	1	.569	.682
MSC T3	.555	.445	.631	.533	1	.618
Maths T3	.496	.674	.487	.671	.670	1

Note. MSC = maths self-concept; Maths = maths marks; T1 = Time 1 (first year); T2 = Time 2 (second year); T3 = Time 3 (third year). Above diagonal = Pearson correlation coefficients for girls attending grades 7 and 8 on Time 1 (cohort A); Under diagonal = Pearson correlation coefficients for boys attending grades 7 and 8 on Time 1 (cohort B). All correlations are significant; $p \leq .000$.

Table A2.
Correlations between maths self-concept and maths marks in cohorts C (above diagonal) and D (under diagonal).

	MSC T1	Maths T1	MSC T2	Maths T2	MSC T3	Maths T3
MSC T1	1	.512	.748	.401	.596	.304
Maths T1	.663	1	.411	.538	.294	.383
MSC T2	.615	.563	1	.640	.704	.421
Maths T2	.440	.571	.697	1	.407	.482
MSC T3	.486	.391	.652	.419	1	.655
Maths T3	.311	.370	.345	.412	.698	1

Note. ASC = maths self-concept; Maths = maths marks; T1 = Time 1 (first year); T2 = Time 2 (second year); T3 = Time 3 (third year). Above diagonal = Pearson correlation coefficients for girls attending grades 9 and 10 on Time 1 (cohort C); Under diagonal = Pearson correlation coefficients for boys attending grades 9 and 10 on Time 1 (cohort D). All correlations are significant; $p \leq .000$.

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