

# VU Research Portal

## Mathematical Thinking, Learning and Performance:

Reed, H.C.

2014

### **document version**

Publisher's PDF, also known as Version of record

[Link to publication in VU Research Portal](#)

### **citation for published version (APA)**

Reed, H. C. (2014). *Mathematical Thinking, Learning and Performance: Insights and interventions for primary and secondary education*. [PhD-Thesis - Research and graduation internal, Vrije Universiteit Amsterdam].

### **General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

### **Take down policy**

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

### **E-mail address:**

[vuresearchportal.ub@vu.nl](mailto:vuresearchportal.ub@vu.nl)

# 8

## **Self-beliefs mediate mathematical performance between primary and lower secondary school: A large-scale longitudinal cohort study**

Helen C. Reed, Paul A. Kirschner and Jelle Jolles

*Submitted*



**ABSTRACT**

This large-scale longitudinal cohort study examines the extent to which mathematics self-concept and academic self-efficacy mediate the relation between mathematical performance at the end of primary school (Grade 6) and the end of lower secondary school (Grade 9) in an educational system with early tracking. The study involves 843 students in the Netherlands, where tracking is employed from the start of secondary school. Mathematics self-concept and academic self-efficacy were measured with self-report questionnaires. Mathematical performance was measured with validated national tests. The relation between mathematical performance in Grade 6 and in Grade 9 was uniquely mediated by both mathematics self-concept in Grade 9 and academic self-efficacy in Grade 6, but in opposing directions. Mathematics self-concept was the most influential mediator, explaining nearly a quarter of this relation. Academic self-efficacy in Grade 6 had a negative influence on Grade 9 mathematical performance. This suggests that self-efficacy needs to be actively managed when students move to secondary school. Findings were similar for both sexes and all educational tracks.

**Keywords:** self-beliefs; self-efficacy; mathematics self-concept; mathematical performance; school transition

## INTRODUCTION

Most students hold beliefs about their own capabilities and competence in accomplishing academic tasks. Do these so-called self-beliefs affect the relation between students' performance at the end of primary school and the end of lower secondary school? This question is especially relevant in systems that stratify students into educational tracks according to scholastic ability. Tracking is based on the premise that homogeneous classes allow curriculum and instruction to be directed towards the common needs of groups of similar ability and that this leads to maximum learning for all (Hanushek & Wößmann, 2006). In systems that make use of early tracking - such as the Netherlands and Germany - track placement in lower secondary school depends to a large extent on performance at the end of primary school or even earlier. An important assumption is that there is a substantial degree of stability in performance between the end of primary school and lower secondary school. If this were not the case, then discrepancies between track placement and students' performance would soon render these systems ineffectual.

It is entirely plausible, however, that the stability of this relation is affected by student variables that could either depress or elevate their actual performance in secondary school relative to expectations at the time of track assignment. Of particular concern are students whose performance in secondary school is below expectation. If these students fail in their designated track, they may have to be retained (i.e., repeat a grade) or drop down to a lower track. Such measures are reported to be detrimental to student outcomes (Brophy, 2006; Jacob & Lefgren, 2009; OECD, 2012b). However, if more is known about student variables that affect the stability of the relation between performance in primary and secondary school, it may be possible to take measures to prevent this happening. Within this context, the present article investigates the extent to which the relation between mathematical performance at the end of primary school (i.e., Grade 6) and the end of lower secondary school (i.e., Grade 9) in an early-tracking educational system (i.e., the Netherlands) is mediated by student self-beliefs.

A large body of research shows that more positive self-beliefs are strongly related to higher performance, as will be reviewed presently. It is therefore worrying that many students experience a decline in self-beliefs between primary and secondary school (Eccles et al., 1993; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). This applies especially to the domain of mathematics. For example, the most recent cycle of the Trends in International Mathematics and Science Study (TIMSS; a periodic international comparative study into educational achievement in mathematics and science) at the time of writing reported that only just over a tenth of 8<sup>th</sup> graders are confident in their mathematics ability compared to a third of 4<sup>th</sup> graders (Mullis, Martin, Foy, & Arora, 2012).

The causes of this decline appear to be manifold. When students move from primary to secondary school, they are confronted with different instructional goals and conditions, classroom cultures, types of academic demands, assessment and grading practices, types of relationships with teachers, types of peer relationships and social needs, as well as biological and neurological changes associated with adolescence. All of these factors can affect their beliefs about their ability to do well in the new school environment (Cauley & Jovanovich, 2006; Eccles et al., 1993; Fenzel, 2000; Liu, Wang, & Parkins, 2005; Midgley, Feldlaufer, & Eccles, 1989; Sakiz, Pape, & Hoy, 2012; Schunk & Meece, 2006; Somerville & Casey, 2010; Urdan & Midgley, 2003; Urdan & Schoenfelder, 2006). Peer influence also becomes stronger in this period, because students are unfamiliar with many of the tasks and learning environments in secondary school and have few sources of information other than their friends with which to gauge their own behaviour and experiences (Schunk & Meece, 2006).

An influential concept in the study of self-beliefs is *self-efficacy*, which concerns individuals' expectations and confidence about their own capabilities and competence in accomplishing given tasks (Bandura, 1997; Bong & Skaalvik, 2003; Schunk & Meece, 2006). These beliefs also influence what individuals choose to do, how much effort they expend, and the extent to which they persist at particular activities when they encounter difficulties. The stronger a person's self-efficacy, the more likely he/she is to engage in goal pursuit and to work harder and persist longer in pursuing those goals (Bandura, 1997; Schunk & Meece, 2006; Wigfield & Eccles, 2002).

Self-efficacy is influenced by diverse personal, social, and contextual factors, of which individuals' own performance and achievement - particularly in comparison to a personally relevant reference group (usually similar peers) - appears to be most influential (Möller, Pohlmann, Köller, & Marsh, 2009; Möller, Retelsdorf, Köller, & Marsh, 2011; Schunk & Meece, 2006; but see Bong & Skaalvik, 2003, for an alternative view). Sensitivity to these influences makes self-efficacy highly task- and situation-specific (Schunk & Meece, 2006; Urdan & Schoenfelder, 2006). Thus, *academic self-efficacy* refers to students' general beliefs about their competence to accomplish academic tasks and do their schoolwork (Bong & Skaalvik, 2003).

A closely related construct is that of *self-concept*, which represents individuals' general perceptions of their own functioning in a given domain; its central element is perceived competence in the domain in question (Bong & Skaalvik, 2003). Self-concept in particular academic areas arises from students' perceptions of previous experiences in these areas, which are shaped by comparisons in relation to personal frames of reference (Möller et al., 2009; Möller et al., 2011; Skaalvik, & Skaalvik, 2002). In this view, students compare their own achievements in a particular area to those of their schoolmates or known grade distributions for their specific environment (i.e., an external frame of reference). The results of these comparisons

shape their conceptions of their competence in a domain-specific way. For example, if their mathematical achievement is higher than that of their schoolmates, students' *mathematics self-concept* will also be higher. At the same time, an internal comparison process, whereby students compare their own achievements across several domains (i.e., an internal frame of reference), may attenuate or inflate self-concept in a particular domain. Thus, independent of actual performance, students may have relatively lower self-concepts in their weakest subjects and relatively higher self-concepts in their strongest subjects.

Previous research has demonstrated strong relationships between academic self-efficacy and academic achievement generally as well as mathematics self-concept and mathematical achievement specifically (Caprara, Vecchione, Alessandri, Gerbino, & Barbaranelli, 2011; Chiu & Klassen, 2010; Ferla, Valcke, & Cai, 2009; Huang, 2011; Ireson & Hallam, 2009; Marsh & Martin, 2011; Möller et al., 2009; Möller et al., 2011; OECD, 2013c; Schunk & Meece, 2006; Skaalvik & Skaalvik, 2006; Steinmayr & Spinath, 2009; Valentine, DuBois, & Cooper, 2004). Strong empirical relations between self-efficacy and self-concept have led to confusion about the conceptual and psychological distinctions between the two, and the comprehensive review of this issue by Bong and Skaalvik (2003) underscores the need for research linking both constructs "within the broader self-system" (p. 30).

### *The present study*

The present study examines the extent to which *academic self-efficacy* and *mathematics self-concept* separately mediate the relation between mathematical performance at the end of primary school (i.e., Grade 6) and the end of lower secondary school (i.e., Grade 9). It draws on a large, homogeneous sample of Dutch students ( $N = 843$ ; age 14.5-15.5 years) who participated in a large-scale, nationally representative, longitudinal cohort study into the determinants of the cognitive and social-emotional development of children and adolescents in the Netherlands. The first and second cohort measurements were used for the present study. The large-scale longitudinal design allows the effects of mathematical performance and self-beliefs to be studied over time.

Academic self-efficacy was measured using the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000; Urdan & Midgley, 2003). This instrument has been validated for use with both primary and secondary school students and is therefore highly suitable for the present purposes. Mathematics self-concept was measured by a single item asking students to indicate how good they think they are at mathematics. A strength of the study is that mathematical performance was measured with validated, standardised national tests rather than school grades. School grades are known to suffer from variability in assessment and grading practices that increases

measurement error (Allen, 2005; Bowers, 2011). The measures used in the present study can therefore be considered a more reliable proxy for mathematical performance. Test scores were standardised within relevant reference groups (i.e., school in Grade 6 and school-plus-track in Grade 9), in order to take students' external frames of reference into account. This is an important point, given that self-beliefs are also shaped by these frames of reference, as discussed.

The research question is investigated in a multiple mediator model that includes measurements at both time points (i.e., Grade 6 and Grade 9). This design allows the effects of earlier measures (i.e., in Grade 6) to be compared with the effects of later measures (i.e., in Grade 9). Inclusion of both academic self-efficacy and mathematics self-concept allows comparison of the effects of domain-general and domain-specific measures. Furthermore, the study examines whether these relations are moderated by sex and/or educational track.

Sex is important to consider because girls and boys have been found to differ in self-beliefs respecting mathematical performance (Herbert & Stipek, 2005; Ireson & Hallam, 2009; Jacobs et al., 2002; Preckel, Goetz, Pekrun, & Kleine, 2008; Schunk & Meece, 2006). International assessments show that girls report lower self-belief in their mathematics ability than boys, even when performance levels are equal (Else-Quest, Hyde, & Linn, 2010; OECD, 2013c). Lower mathematical self-beliefs in girls are related to lower enrolment in mathematics-related courses in senior secondary school and higher education and lower participation of females in STEM-related (science, technology, engineering and mathematics) professions (Crombie et al., 2005; Meelissen & Luyten, 2008; Van Langen, Rekers-Mombarg, & Dekkers, 2006).

Educational track can be expected to influence the results due to the so-called 'Big-Fish-Little-Pond' effect (Marsh, 1991; Marsh & Hau, 2003). The central assumption, as already discussed, is that self-beliefs are influenced by comparing one's own performance with that of one's immediate peers. Thus, once students have moved from heterogeneous primary school classrooms into ability-homogeneous tracks in secondary school, the corresponding change in reference peer group is likely - over time - to depress self-beliefs in higher tracks and increase them in lower tracks. This is particularly so where there is little academic contact between students in different tracks, so that within-track (as opposed to across-track) comparisons become dominant (Liu et al., 2005). The Netherlands is particularly suitable for studying these effects, since tracking is implemented early in secondary school. Tracks are differentiated according to certain levels of general academic ability: *pre-university* (preparing the most able students for university), *higher general secondary* (preparing able students for professional higher education), *pre-vocational* (providing practice-oriented or theory-oriented preparation for vocational education), and *practical training* (preparing the least able students with practical skills with which to enter the

workforce). Once students' track placement has been determined (sometimes after an initial orienting period), there is little academic contact (e.g., shared classes) across tracks. Thus, in terms of within-track versus across-track comparisons, the former is likely to play a stronger role over time.

In short, the present study provides insights into the extent to which self-beliefs influence the relation between mathematical performance at the end of primary school and the end of lower secondary school in an early tracking educational system. In addition, it provides indications as to the relative importance of domain-general and domain-specific self-beliefs, as well as the relative importance of beliefs held at the end of primary school and the end of lower secondary school. The large-scale longitudinal design combined with the use of validated self-report and performance measures allows strong inferences to be drawn about the relations of interest. The results could therefore be of considerable value in helping educators develop interventions to prevent performance in secondary school from dropping below levels expected in designated tracks.

## METHODS

Data were obtained from the first and second cohort measurements of the COOL<sup>5-18</sup> study (Cohort Onderzoek Onderwijs Loopbanen; Cohort Research on Educational Careers), a large-scale, nationally representative, longitudinal cohort study into the determinants of the cognitive and social-emotional development of children and adolescents in the Netherlands. The study was commissioned by the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Education, Culture and Science and was carried out by a broad consortium of research and assessment organisations in the Netherlands. The datasets are available for third-party use (e.g., the present study) and can be obtained from the website of Data Archiving Network Services (DANS); <http://www.dans.knaw.nl>). The technical reports, including full descriptions of participants, methods and procedures, are also available from DANS, as well as from the study website (<http://www.cool5-18.nl/>; Driessen, Mulder, Ledoux, Roeleveld, & Van der Veen, 2009; Zijssling, Keuning, Naayer, & Kuyper, 2012).

The first cohort measurement of the COOL<sup>5-18</sup> study included  $N = 11,609$  Grade 6 students from 550 primary schools. The second measurement included  $N = 21,384$  Grade 9 students from 151 secondary schools. A total of  $N = 2,646$  students from 355 primary schools and 143 secondary schools participated in the first measurement when in Grade 6 and in the second measurement when in Grade 9. Participants took several cognitive tests at each measurement, including a mathematics test. They also completed a self-report questionnaire, which included scales from externally validated questionnaires on topics including self-efficacy and school functioning. Parents/caregivers completed a demographic questionnaire and schools provided



administrative data (e.g., age, sex, educational track). As far as can be ascertained from the technical report, missing data was not biased. The following paragraphs describe the participants, instruments and data relevant to the present study.

### **Participants**

Individuals were selected for the present study when they had participated in the COOL<sup>5-18</sup> study in both Grade 6 and Grade 9, when they had Dutch nationality and when complete data were available for sex, educational track, both mathematics tests (i.e., in Grade 6 and Grade 9), and all of the predictors (i.e., self-efficacy in Grades 6 and 9; mathematics self-concept (measured only in Grade 9)). In addition, students had to be aged between 14.5 and 15.5 years at Grade 9 measurement. The choice for an age-restricted window was in order to have a relatively homogeneous sample. Accelerated and delayed students were excluded, as these students differ from their classmates in several respects that could confound the results (Jimerson & Ferguson, 2007; Steenbergen-Hu & Moon, 2011). The sample comprised  $N = 843$  students (47% male ( $N = 394$ );  $M_{age} = 14.9$  years,  $SD = 0.3$ ). Of these,  $N = 329$  (39%) were in a 'low' track (i.e., practical training and pre-vocational education),  $N = 235$  (28%) were in a 'medium' track (i.e., higher general secondary education) and  $N = 279$  (33%) were in a 'high' track (i.e., pre-university education). The selected students came from 188 primary schools and 101 secondary schools.

### **Grade 6 instruments and data**

#### *Mathematical performance (variable: ZMATHG6)*

Participants were administered a standardised, norm-referenced nationwide test for Grade 6 developed by the Dutch Central Institute for Educational Measurement (CITO; M8, version 2002). The test contains 107 items covering: (1) numbers and number relations; (2) arithmetic fact fluency; (3) mental arithmetic; (4) problems involving multiple operations; (5) fractions; (6) proportions; (7) percentages; (8) measurement; (9) geometry; (10) time. Raw test scores were converted to proficiency scores in the range 54 to 160 following the test procedure and nationally established norms. One case with an input error (i.e., score < 54) was excluded from analysis. Proficiency scores were standardised per school over the whole COOL<sup>5-18</sup> Grade 6 sample to denote performance relative to a relevant reference group. The standardised scores were used as the measure for Grade 6 mathematical performance. The correlation between the standardised and unstandardised scores was very high ( $r = .82, p < .001$ ).

#### *Academic self-efficacy (variable: SEFFG6)*

Academic self-efficacy was measured by the self-efficacy scale of the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000; Urdan & Midgley, 2003)

included in the student questionnaire. The self-efficacy scale contains six items (e.g., “I’m certain I can master the skills taught in school this year” and “Even if the work is hard, I can learn it”), rated on a 5-point Likert-type scale with choice options ranging from ‘not at all true’ to ‘very true’. Items were translated into Dutch and coded from 1 to 5, with higher scores indicating higher self-efficacy. Scale internal reliability was acceptable (Cronbach’s  $\alpha = .78$ ). Academic self-efficacy was calculated as the average of the six items.

### Grade 9 instruments and data

#### *Mathematical performance (variable: ZMATHG9)*

Participants were administered a multiple-choice mathematics test constructed by the Dutch Central Institute for Educational Measurement. Test items were drawn from an item-bank of 60 items and were administered in three test versions comprising 30 multiple-choice items on arithmetic, proportions, geometry and mathematical relationships. Each item had four response options and participants had to underline their choice on an answer sheet. Example items are shown in the boxes.

*Example 1: A group of 5 men in a company buys one lottery ticket between them every month. A group of 8 women does the same. There is one lottery draw per month. Everyone can see then which tickets have won prizes. If a prize is won by one of the groups’ tickets, then the prize is shared out among the group members: among the 5 members of the men’s group and among the 8 members of the women’s group. In April 2009, the ticket bought by the men’s group won a prize of 100,000 Euros. At the same time, the ticket bought by the women’s group won a prize of 200,000 Euros. With this lottery result, each man received an amount of money and each woman received another amount of money. The amount that each man received was:*

- A             $\frac{4}{5}$  times the amount that each woman received*
- B             $\frac{5}{8}$  times the amount that each woman received*
- C             $\frac{5}{4}$  times the amount that each woman received*
- D             $\frac{8}{5}$  times the amount that each woman received*

Items were analysed using the One-Parameter Logistic Model (OPLM; Verhelst & Glas, 1995) from Item Response Theory. The OPLM was used to translate raw test scores to skill-scores that were in turn translated to bank-scores on a scale of 0 to 100% (Hambleton, Swaminathan, & Rogers, 1991). The bank-score indicates individual mastery level (e.g., a bank-score of 70 means that the student is expected to answer 70% of the total item-bank correctly) and is directly comparable across

*Example 2: This question is about a row of figures that are made up of dots. The figures are made following a fixed pattern. The first four figures of the row are shown below.*



*The number of dots in the 10th figure is:*

- A      72
- B      73
- C      80
- D      81

participants and test versions. Bank-scores were standardised per school and educational track over the whole COOL<sup>5-18</sup> Grade 9 sample to denote performance relative to a relevant reference group. The standardised scores were used as the measure for Grade 9 mathematical performance. The correlation between the standardised and unstandardised scores was high ( $r = .56, p < .001$ ).

*Academic self-efficacy (variable: SEFFG9)*

As in Grade 6, academic self-efficacy was measured by the self-efficacy scale of the Patterns of Adaptive Learning Scales (Midgley et al., 2000; Urdan & Midgley, 2003) included in the student questionnaire, coded as described above. Scale internal reliability was acceptable (Cronbach’s  $\alpha = .83$ ). Academic self-efficacy was calculated as the average of the scale items.

*Mathematics self-concept (variable: MCOMP9)*

Mathematics self-concept was measured by the item: “*I am good at arithmetic and mathematics*” from the student questionnaire. The item (in Dutch) had choice options ‘disagree’, ‘partly agree’ and ‘agree’ and was coded from 1 to 3, with higher scores indicating a higher opinion of students’ own competence. Single-item measures are frequently used in research on self-beliefs, for example by having participants indicate an anticipated exam grade (e.g., Vancouver & Kendall, 2006). Research has shown that a single, omnibus measure with an answer format that interrupts respondents’ response styles after a series of Likert-type items can be as psychometrically sound and effective as multiple-item measurement scales in self-report questionnaires

(Gardner, Cummings, Dunham, & Pierce, 1998; Robins, Hendin, & Trzesniewski, 2001). Single-item measures reduce undesirable response behaviours - such as skipping questions that closely resemble previous ones - and eliminate item redundancy and variance due to spurious correlations between highly related items. For example, Möller et al. (2011) measured mathematics self-concept with 3 items (“*Math is one of my best subjects*”; “*In math, I do quite well*”; “*In math, I usually get good grades.*”). The resulting reliabilities of the self-concept scale at different time points were extremely high (Cronbach’s  $\alpha$  of .90 to .91), suggesting redundancy.

Descriptive statistics for these measures are shown in Table 8.1 and Pearson correlations are given in Table 8.2.

Table 8.1  
*Descriptive statistics main variables*

	Full sample		Sex				Educational Track					
			Male		Female		Low		Medium		High	
	<i>N</i> = 843		<i>N</i> = 394		<i>N</i> = 449		<i>N</i> = 329		<i>N</i> = 235		<i>N</i> = 279	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Grade 6:												
ZMATHG6 <sup>a</sup>	0.25	0.91	0.46	0.89	0.06	0.89	-0.35	0.77	0.33	0.71	0.88	0.75
SEFFG6	3.71	0.58	3.80	0.56	3.63	0.59	3.50	0.57	3.78	0.57	3.90	0.51
Grade 9:												
ZMATHG9 <sup>b</sup>	0.10	0.95	0.30	0.92	-0.08	0.95	0.27	0.94	0.04	0.88	-0.06	1.00
SEFFG9	3.48	0.64	3.61	0.62	3.37	0.63	3.41	0.64	3.46	0.60	3.59	0.65
MCOMP9	2.13	0.77	2.26	0.72	2.01	0.79	2.07	0.76	2.07	0.76	2.24	0.77

Notes. <sup>a</sup> Standardised across full COOL<sup>5-18</sup> Grade 6 sample (*N* = 11,609). <sup>b</sup> Standardised across full COOL<sup>5-18</sup> Grade 9 sample (*N* = 21,384).

**Analysis**

Analyses were performed in IBM SPSS Statistics 20® ( $\alpha$  = .05). First, to establish whether between-subjects differences were present for the main variables, MANOVA with posthoc comparisons (Bonferroni correction) was performed with *sex* and *track* as between-subjects factors and *age* as a covariate. Then, to establish the extent to which temporal changes (i.e., between Grade 6 and Grade 9) were present, a GLM Repeated Measures analysis with posthoc comparisons (Bonferroni correction) was

Table 8.2  
*Pearson correlations between main variables and with age*

	Total <i>N</i> = 843	Sex		Educational Track		
		Males	Females	Low	Medium	High
		<i>N</i> = 394	<i>N</i> = 449	<i>N</i> = 329	<i>N</i> = 235	<i>N</i> = 279
ZMATHG6-ZMATHG9	.33***	.37***	.23***	.53***	.46***	.52***
ZMATHG6-SEFFG6	.34***	.29***	.35***	.25***	.20**	.19**
ZMATHG6-SEFFG9	.17***	.12*	.14**	.12*	.11	.15*
ZMATHG6-MCOMP9	.29***	.27***	.26***	.29***	.30***	.29***
ZMATHG9-SEFFG6	.06	.11*	-.02	.17**	.13*	.04
ZMATHG9-SEFFG9	.17***	.14**	.13**	.24***	.07	.21***
ZMATHG9-MCOMP9	.35***	.30***	.36***	.35***	.35***	.41***
SEFFG6-SEFFG9	.34***	.37***	.28***	.35***	.31***	.31***
SEFFG6-MCOMP9	.13***	.10	.13**	.07	.20**	.10
SEFFG9-MCOMP9	.35***	.32***	.34***	.26***	.30***	.49***
AGE-ZMATHG6	-.12***	-.12*	-.13**	-.14*	-.08	-.09
AGE-ZMATHG9	-.11**	-.15**	-.08	-.12*	-.11	-.13*
AGE-SEFFG6	-.04	-.03	-.06	-.07	.06	-.07
AGE-SEFFG9	-.05	-.08	-.03	-.04	-.05	-.03
AGE-MCOMP9	-.10**	-.08	-.11*	-.09	-.11	-.07

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

performed with *sex* and *track* as between-subjects factors and *age* as a covariate. Academic self-efficacy (*self-efficacy*) and standardised mathematical performance (*math performance*) were the outcome measures and *time* (i.e., Grade 6 versus Grade 9) was the within-subjects factor.

Next, a multiple mediator model was used to determine whether the effect of *mathematical performance in Grade 6 (ZMATHG6)* on *mathematical performance in Grade 9 (ZMATHG9)* is mediated by *academic self-efficacy (SEFFG6, SEFFG9)* and *mathematics self-concept (MCOMP9)*. It should be noted that a mediation model is a causal model, referring to a sequence of relations in which an independent variable affects a dependent variable by influencing intervening (i.e., mediator) variables. The causal order of the variables must be established on theoretical, logical or procedural grounds (Hayes, 2013). As previous research has demonstrated reciprocal effects

between mathematical performance and both academic self-efficacy and mathematics self-concept (Marsh & Martin, 2011; Möller et al., 2011; Pajares & Schunk, 2001), it is plausible to assume that: (a) mathematical performance at an earlier time point (i.e., Grade 6) could affect mathematical performance at a later time point (i.e., Grade 9); (b) mathematical performance at an earlier time point could influence students' self-efficacy beliefs and their mathematics self-concept both concurrently and at a later time point; and (c) students' self-efficacy beliefs and mathematics self-concept could affect subsequent mathematical performance. The mediator model is depicted in Figure 8.1.

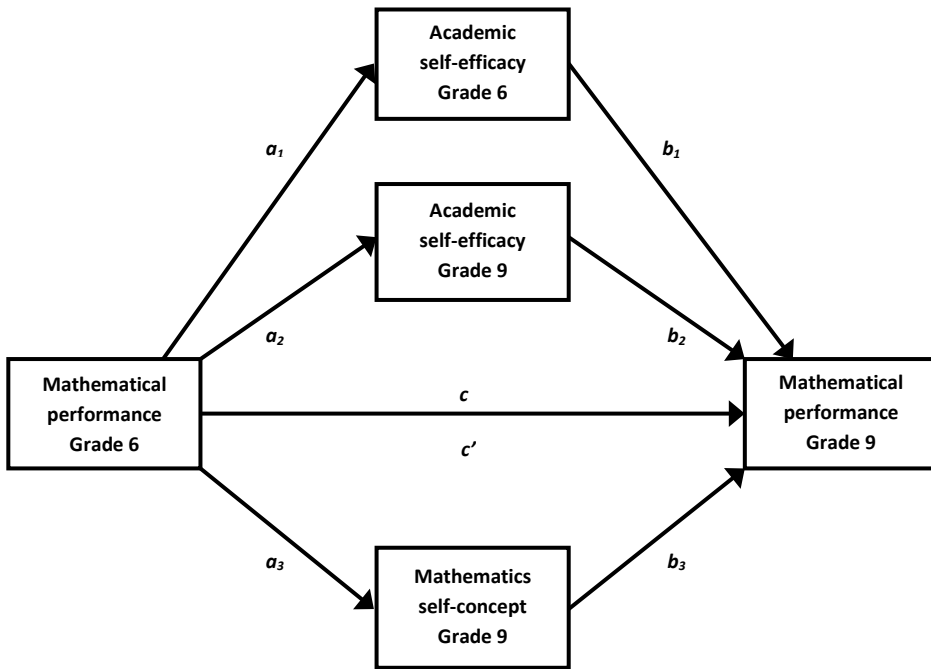


Figure 8.1. Multiple mediator model

The  $a_i$  paths represent the effect of  $ZMATHG6$  on the proposed mediators. The  $b_i$  paths represent the effect of the proposed mediators on  $ZMATHG9$ , partialling out the effect of  $ZMATHG6$ . Path  $c$  represents the total effect of  $ZMATHG6$  on  $ZMATHG9$  and path  $c'$  represents the direct effect of  $ZMATHG6$  on  $ZMATHG9$  after controlling for the proposed mediators. The specific indirect effect of  $ZMATHG6$  on  $ZMATHG9$  through a particular mediator (i.e., the unique ability of the mediator to mediate the effect of  $ZMATHG6$  on  $ZMATHG9$  conditional on the other mediators) is the product of the two paths linking  $ZMATHG6$  to  $ZMATHG9$  via that mediator (i.e.,  $a_i * b_i$ ). The total indirect

effect of *ZMATHG6* on *ZMATHG9* is the sum of the specific indirect effects. The total effect of *ZMATHG6* on *ZMATHG9* (path *c*) is the sum of the direct effect and all of the specific indirect effects.

As mediator collinearity could affect the outcomes of the analysis (Hayes, 2013; Marsh, Dowson, Pietsch, & Walker, 2004), Variance Inflation Factors (VIF) and tolerances were first calculated. A VIF less than 2.5 and tolerance greater than 0.40 were taken to indicate absence of collinearity. Then, Hayes' (2013) bootstrapping method, implemented in his PROCESS macro (obtained from <http://www.afhayes.com/spss-sas-and-mplus-macros-and-code.html>), was used to test the indirect effects of the hypothesised mediators with age as a covariate (Model 4 in the PROCESS macro). The bootstrapping procedure does not make assumptions about the sampling distribution of the indirect effects or force choices about estimation or constraint of residual covariances. It resamples thousands of times from the data set and estimates the indirect effects in each resample, thereby providing an empirical approximation of and confidence intervals for these effects. An indirect effect is significant if the 95% confidence interval (i.e., at the  $\alpha$ -level of this study) does not contain zero. Bias-corrected confidence intervals were used, as indirect effects usually have a skewed distribution. A heteroscedasticity-consistent standard error estimator was used, which reduces the likelihood that inference validity is compromised by any potential violation of homoscedasticity. Effect size was calculated as the ratio of the indirect effect ( $a_i * b_i$ ) to the total effect of *ZMATHG6* on *ZMATHG9* (*c*) (Preacher & Kelley, 2011). Simple contrasts between each pair of proposed mediators were used to identify the most influential mediator(s) overall.

Finally, two moderated mediation analyses tested whether mediation effects differed for sex and educational track, that is, whether the strength of the indirect effects is conditional on sex and/or track. Moderation of all relationships in the model (i.e., between *ZMATHG6* and *ZMATHG9*, between *ZMATHG6* and each mediator, and between each mediator and *ZMATHG9*) was tested (Model 59 in the PROCESS macro). The so-called conditional indirect effect of a specific mediator estimates the indirect effect of that mediator at specified values of the moderator. For dichotomous moderators, these values represent the two groups. For moderation by sex, males were the reference group. For moderation by track, two dummy variables were created with the medium track as reference group. The model was then estimated twice: each time one of the dummy variables was designated the moderator and the other a covariate. The conditional indirect effects then estimated the indirect effect of each mediator in (a) the low and medium tracks and (b) the medium and high tracks. The so-called Index of Moderated Mediation (IMM) produced by the PROCESS macro tests the equality of the conditional indirect effects in the groups being compared. When the index is not significant, these effects are equivalent.

## RESULTS

### *Between-subjects differences*

There was a medium-large effect of *sex* (Wilks'  $\lambda = .88$ ,  $F(5,832) = 22.21$ ,  $p < .001$ ,  $\eta_p^2 = .12$ ), a large effect of *track* (Wilks'  $\lambda = .52$ ,  $F(10,1664) = 64.15$ ,  $p < .001$ ,  $\eta_p^2 = .28$ ) and a small effect of *age* (Wilks'  $\lambda = .98$ ,  $F(5,832) = 3.48$ ,  $p = .004$ ,  $\eta_p^2 = .02$ ). There was no interaction between *sex* and *track*. The univariate tests showed that males had significantly higher scores than females on all variables (*SEFFG6*:  $F(1,836) = 24.22$ ,  $p < .001$ ,  $\eta_p^2 = .03$ ; *SEFFG9*:  $F(1,836) = 32.63$ ,  $p < .001$ ,  $\eta_p^2 = .04$ ; *MCOMP9*:  $F(1,836) = 24.72$ ,  $p < .001$ ,  $\eta_p^2 = .03$ ; *ZMATHG6*:  $F(1,836) = 78.79$ ,  $p < .001$ ,  $\eta_p^2 = .09$ ; *ZMATHG9*:  $F(1,836) = 34.91$ ,  $p < .001$ ,  $\eta_p^2 = .04$ ). *Tracks* also differed on all variables (*SEFFG6*:  $F(2,836) = 44.85$ ,  $p < .001$ ,  $\eta_p^2 = .10$ ; *SEFFG9*:  $F(2,836) = 6.20$ ,  $p = .002$ ,  $\eta_p^2 = .01$ ; *MCOMP9*:  $F(2,836) = 4.43$ ,  $p = .012$ ,  $\eta_p^2 = .01$ ; *ZMATHG6*:  $F(2,836) = 225.05$ ,  $p < .001$ ,  $\eta_p^2 = .35$ ; *ZMATHG9*:  $F(2,836) = 9.64$ ,  $p < .001$ ,  $\eta_p^2 = .02$ ). *SEFFG6* and *ZMATHG6* were lowest in the lowest track and *ZMATHG6* was highest in the highest track (all  $p_{Bonf} < .001$ ). In contrast, *ZMATHG9* was highest in the lowest track (all  $p_{Bonf} < .03$ ). The highest track also scored higher than the lowest track on *SEFFG9* and *MCOMP9* (all  $p_{Bonf} < .02$ ). *Age* affected *MCOMP9* ( $F(1,836) = 7.02$ ,  $p = .008$ ,  $\eta_p^2 = .01$ ) and both math measures (*ZMATHG6*:  $F(1,836) = 10.42$ ,  $p = .001$ ,  $\eta_p^2 = .01$ ; *ZMATHG9*:  $F(1,836) = 12.39$ ,  $p < .001$ ,  $\eta_p^2 = .01$ ) but not *self-efficacy*. Pearson correlations (see Table 8.2) indicated that these variables were lower for older students.

### *Temporal changes*

There was a medium-large effect of *sex* (Wilks'  $\lambda = .90$ ,  $F(2,835) = 48.70$ ,  $p < .001$ ,  $\eta_p^2 = .10$ ), a medium effect of *track* (Wilks'  $\lambda = .89$ ,  $F(4,1670) = 24.96$ ,  $p < .001$ ,  $\eta_p^2 = .06$ ), a small effect of *age* (Wilks'  $\lambda = .98$ ,  $F(2,835) = 7.95$ ,  $p < .001$ ,  $\eta_p^2 = .02$ ) and a large *time* x *track* interaction (Wilks'  $\lambda = .62$ ,  $F(4,1670) = 112.42$ ,  $p < .001$ ,  $\eta_p^2 = .21$ ). There was no main effect of *time* and there were no interactions between *sex* and *time*, *sex* and *track*, *time* and *age*, or any 3-way interaction.

The univariate tests showed that males had higher *self-efficacy* ( $F(1,836) = 43.63$ ,  $p < .001$ ,  $\eta_p^2 = .05$ ) and *math performance* ( $F(1,836) = 70.07$ ,  $p < .001$ ,  $\eta_p^2 = .08$ ) than females, corresponding to the MANOVA results. *Tracks* also differed on *self-efficacy* ( $F(2,836) = 29.02$ ,  $p < .001$ ,  $\eta_p^2 = .06$ ) and *math performance* ( $F(2,836) = 31.31$ ,  $p < .001$ ,  $\eta_p^2 = .07$ ), both of which were lowest in the lowest track and highest in the highest track (all  $p_{Bonf} \leq .01$ ). Older students had lower *math performance* ( $F(1,836) = 15.53$ ,  $p < .001$ ,  $\eta_p^2 = .02$ ) but *self-efficacy* was not affected by *age*. These effects were in the context of a small *time* x *track* interaction for *self-efficacy* ( $F(2,836) = 11.89$ ,  $p < .001$ ,  $\eta_p^2 = .03$ ), with the lowest track showing a much smaller decline in *self-efficacy* than the other two tracks, and a large interaction for *math performance* ( $F(2,836) = 250.87$ ,  $p < .001$ ,  $\eta_p^2 = .38$ ). For the lowest track, *math*



*performance* in Grade 9 (standardised relative to reference group) was substantially higher than in Grade 6, while the reverse was true for the two higher tracks.

### *Mediation analysis*

Collinearity was not present, as all VIFs were below 2.5 and all tolerances were above 0.40. The bootstrapping estimates for the multiple mediator model are presented in Table 8.3.

Table 8.3  
*Bootstrapping results mediation analysis*

	Point Estimate	Boot SE	ES	95% CI		B	SE	t	p
				lower	upper				
Total effect (c path)	0.33	0.03						10.48	<.001
Direct effect (c' path)	0.28	0.03						8.30	<.001
Age (covariate)						-0.23	0.11	-2.21	.03
Indirect effects:									
Total indirect	0.06	0.02	0.17	0.02	0.10				
SEFFG6	-0.03	0.01	0.09	-0.06	-0.00				
a path						0.22	0.02	10.37	<.001
b path						-0.14	0.06	-2.37	.02
SEFFG9	0.01	0.01	0.03	-0.00	0.02				
a path						0.11	0.02	5.01	<.001
b path						0.08	0.05	1.50	.13
MCOMP9	0.08	0.01	0.23	0.05	0.11				
a path						0.24	0.03	8.13	<.001
b path						0.33	0.05	7.30	<.001
Contrasts:									
SEFFG6-SEFFG9	-0.04	0.02		-0.07	-0.01				
SEFFG6-MCOMP9	-0.11	0.02		-0.15	-0.07				
SEFFG9-MCOMP9	-0.07	0.02		-0.10	-0.04				

Notes. 5000 bootstrap samples.  $\alpha = .05$ . ES (effect size) = indirect effect/total effect.

The total model explained 11% of variance in *ZMATHG9* ( $F(2,840) = 60.60$ ,  $p < .001$ ). There were significant total and direct effects of *ZMATHG6* on *ZMATHG9*, and the total indirect effect through the hypothesised mediators was also significant. The specific indirect effects showed that *SEFFG6* (Est = -0.03, Boot SE = 0.01, ES = 0.09, 95% CI: -0.06 to -0.00) and *MCOMP9* (Est = 0.08, Boot SE = 0.01, ES = 0.23, 95% CI: 0.05 to 0.11) each uniquely mediated the relationship between *ZMATHG6* and *ZMATHG9*, but in different directions. *SEFFG9* did not mediate this relationship. Simple contrasts indicated that the specific indirect effect through *MCOMP9* was most influential, explaining 23% of the total effect of *ZMATHG6* on *ZMATHG9*. The direction of the **a** and **b** paths indicated that: (a) higher mathematical performance in Grade 6 leads to higher mathematics self-concept in Grade 9, which has a positive influence on Grade 9 mathematical performance; (b) higher mathematical performance in Grade 6 leads to higher academic self-efficacy in Grade 6, and this has a negative influence on Grade 9 mathematical performance.

*Moderation by sex.* There were no interactions of sex with any of the paths in the model. The conditional indirect effect of *SEFFG6* was significant for females (Est = -0.05, Boot SE = 0.02, 95% CI: -0.09 to -0.02). The effect was in the same direction for males, but not significant. The IMM indicated that the sex difference was not significant (IMM = -0.05, Boot SE = 0.03, 95% CI: -0.10 to 0.00). The conditional indirect effect of *SEFFG9* was not significant for either sex nor was there a difference between sexes (IMM = -0.00, Boot SE = 0.01, 95% CI: -0.02 to 0.02). The conditional indirect effect of *MCOMP9* was significant for both males (Est = 0.05, Boot SE = 0.02, 95% CI: 0.02 to 0.10) and females (Est = 0.08, Boot SE = 0.02, 95% CI: 0.05 to 0.13) and these effects were equivalent (IMM = 0.03, Boot SE = 0.03, 95% CI: -0.02 to 0.08). Thus, there was no moderation by sex and the relation between *ZMATHG6* and *ZMATHG9* via the hypothesised mediators was the same for males and females.

*Moderation by track.* There were no interactions of track with any of the paths in the model. In the model comparing the medium and low tracks, the conditional indirect effect of *SEFFG6* was not significant for either track. The conditional indirect effect of *SEFFG9* was significant for the low track (Est = 0.02, Boot SE = 0.01, 95% CI: 0.00 to 0.05) but not for the medium track. The conditional indirect effect of *MCOMP9* was significant for both tracks (Low: Est = 0.06, Boot SE = 0.02, 95% CI: 0.03 to 0.11; Medium: Est = 0.10, Boot SE = 0.02, 95% CI: 0.06 to 0.15). None of the conditional indirect effects differed between the low and medium tracks (IMM(*SEFFG6*) = 0.05, Boot SE = 0.02, 95% CI: -0.04 to 0.04; IMM(*SEFFG9*) = 0.02, Boot SE = 0.01, 95% CI: -0.00 to 0.06; IMM(*MCOMP9*) = -0.03, Boot SE = 0.03, 95% CI: -0.09 to 0.03).

In the model comparing the medium and high tracks, the conditional indirect effect of *SEFFG6* was significant for the high track (Est = -0.02, Boot SE = 0.01, 95% CI: -0.05

to -0.00) but not for the medium track. The conditional indirect effect of *SEFFG9* was not significant for either track. The conditional indirect effect of *MCOMPG9* was again significant for both tracks (Medium: Est = 0.07, Boot *SE* = 0.02, 95% CI: 0.04 to 0.11; High: Est = 0.10, Boot *SE* = 0.03, 95% CI: 0.05 to 0.17). None of the conditional indirect effects differed between the medium and high tracks (IMM(*SEFFG6*) = -0.02, Boot *SE* = 0.02, 95% CI: -0.06 to 0.01; IMM(*SEFFG9*) = -0.00, Boot *SE* = 0.01, 95% CI: -0.03 to 0.03; IMM(*MCOMPG9*) = 0.03, Boot *SE* = 0.03, 95% CI: -0.03 to 0.10). Taken together, these results means that track did not moderate the relation between *ZMATHG6* and *ZMATHG9* via the hypothesised mediators.

## DISCUSSION

This study set out to understand the extent to which self-beliefs mediate the relation between mathematical performance at the end of primary school (i.e., Grade 6) and the end of lower secondary school (i.e., Grade 9) in an educational system that makes use of early tracking. The study involved 843 Dutch students who participated in a large-scale, longitudinal cohort study in the Netherlands. In interpreting the results, it is important to remember that self-beliefs are shaped by the comparison of oneself with relevant reference groups (Möller et al., 2009; Möller et al., 2011; Schunk & Meece, 2006) and that mathematical performance was standardised on the same basis. While Grade 6 students can compare themselves to classmates of all ability levels (i.e., a heterogeneous comparison group), the highly differentiated tracking structure of Dutch secondary education means that Grade 9 students - who are established in ability-homogeneous tracks - are likely to compare themselves to classmates in the same track as themselves. The corresponding change in reference group is likely over time to depress self-beliefs as well as relative mathematical performance in higher tracks and increase them in lower tracks (Liu et al., 2005; Marsh, 1991; Marsh & Hau, 2003). Indeed, exactly this pattern was found for mathematical performance, and - despite a general decline in self-efficacy from Grade 6 to Grade 9 - the lowest track showed a much smaller decline than the two higher tracks.

*Academic self-efficacy* in Grade 6 and *mathematics self-concept* in Grade 9 both uniquely mediated the relation between mathematical performance in Grade 6 and in Grade 9, but self-efficacy in Grade 9 did not add anything to the mediation effects. It should be noted that the mediation analysis method used here focuses on the unique contribution of each proposed mediator. Although there was no excessively high relation between the concurrent measures of self-efficacy and mathematics self-concept in Grade 9, it is possible that the existing degree of overlap could have diminished the unique contribution of the former when the latter was taken into account.

*Mathematics self-concept* was the most influential mediator, explaining nearly a quarter of the relation between mathematical performance in Grade 6 and in Grade 9. Thus, domain-specific self-beliefs were more influential than domain-general self-beliefs, which is consistent with previous research (Valentine et al., 2004). Although causality cannot be definitely determined from these data, even with the longitudinal design, the findings suggest that higher mathematical performance in Grade 6 leads to higher mathematics self-concept in Grade 9 which, in turn, positively influences Grade 9 mathematical performance. These results are in line with previous research that has demonstrated reciprocal effects between mathematics self-concept and performance: self-concept influences outcomes (thus, performance is improved by enhancing self-concept) and outcomes influence one's self-perceptions (thus, self-concept is enhanced by developing stronger skills) (Marsh & Martin, 2011; Möller et al., 2011).

With the same caveat regarding causality, higher *academic self-efficacy* in Grade 6 appears to have a negative influence on Grade 9 mathematical performance and this effect is the same in all tracks. Thus, if students feel academically competent at the end of primary school, this may lead to lower mathematical performance at the end of lower secondary school. This finding runs counter to the large body of research indicating that self-efficacy has a positive influence on performance (Ferla et al., 2009; Schunk & Meece, 2006; Skaalvik & Skaalvik, 2006; Valentine et al., 2004). Several explanations are plausible. First, students who enter secondary school confident that they will succeed at academic tasks may be tempted to allocate less study time to their schoolwork than students who are less confident of their abilities (cf. Vancouver & Kendall, 2006). Given the more exacting demands and conditions of secondary school, this approach is likely to produce lower performance, however. A second possibility is that disparities between the learning environments in primary and secondary school could mean that learning strategies that have served well in primary school may be less effective - or even counterproductive - in secondary school. Thus, students who persist in using such strategies could be at a disadvantage when dealing with schoolwork in secondary school. For example, students who make use of a rote-learning strategy in primary school and who continue to use this strategy are likely to encounter problems when required to master concepts and solve novel problems in secondary school (Mayer, 2002). Also, students with unrealistically high self-efficacy are often overconfident of their study methods and unwilling to change them (Schunk & Pajares, 2004). This may particularly be an issue for boys, who tend to overestimate their capabilities (Pajares, 2002). A third possibility is that students who enter secondary school believing that they will be successful face a harder 'reality check' when confronted with more demanding environments. This may produce distress that diverts attention away from learning and towards re-establishing well-being

(Boekaerts, 2006). Furthermore, initial problems encountered after school transition could set students on a downward path that they may not easily recover from. In any case, contrary to commonly-held views, it is clear that higher self-efficacy at the end of primary school is not necessarily a protective factor if not appropriately managed when students move to secondary school.

Sex did not moderate the results. Previous research reports differences in self-beliefs between boys and girls respecting mathematical performance (Else-Quest et al., 2010; Herbert & Stipek, 2005; Ireson & Hallam, 2009; Jacobs et al., 2002; OECD, 2013c; Preckel et al., 2008; Schunk & Meece, 2006). In the present study, boys also had higher self-beliefs than girls, but this did not significantly affect the relation between mathematical performance in Grade 6 and in Grade 9 through the given mediators. Thus, the mechanisms proposed above appear to be equally valid for both sexes.

#### *Educational implications*

It is often argued that enhancement of self-beliefs should be one of the key goals of education (Marsh & Martin, 2011; Möller et al., 2009; OECD, 2013c; Schunk & Meece, 2006). This study also showed that mathematics self-concept is extremely influential in mediating the relationship between mathematical performance in primary and in lower secondary school. While we do not dispute the importance of positive self-beliefs for successful outcomes in school and beyond, the present study adds a qualification to these arguments. The findings strongly suggest that it is essential to actively manage students' self-beliefs during particular periods of schooling, such as the transition between primary school and the first years of secondary school. If enhancement initiatives try to improve self-beliefs without regard to the realities of the circumstances that students face or to their ability to adapt learning strategies to different environments, there is a danger that this could be detrimental to performance. In fact, unrealistically high self-beliefs are linked to lower performance (Chiu & Klassen, 2010; Vancouver & Kendall, 2006). An implication of this is that attention to self-beliefs should be part of an integral pedagogical approach that addresses issues such as coping with school transition and learning to adapt one's study strategies (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Cauley & Jovanovich, 2006; Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Qualter, Whiteley, Hutchinson, & Pope, 2007), as well as increasing self-knowledge about causes and consequences of behaviour and study outcomes (Blakemore, 2010; Dekker, 2013). This may in turn improve the accuracy of students' self-beliefs (Schunk & Pajares, 2004).

Furthermore, much attention to managing self-beliefs - especially with regard to mathematics - is aimed at girls (e.g., Good, Aronson, & Inzlicht, 2003; Johns, Schmader,

& Martens, 2005; OECD, 2013c; Preckel et al., 2008). However, the present findings indicate that boys' self-beliefs are as susceptible as girls' in the period studied and show the same patterns in the relationship to mathematical performance. Given the strong relation between self-beliefs and achievement, unrealistic self-beliefs could well contribute to the high incidence of boys among underachieving or failing students (Driessen & Van Langen, 2010; Lamb, Markussen, Teese, Sandberg, & Polesel, 2011). Thus, attention to managing self-beliefs should be extended to boys.

#### *Future research*

The present study has a number of strengths that underscore its value for educators and researchers who wish to understand the influence of self-beliefs on mathematics performance: specifically, the large-scale longitudinal design, the use of validated self-report and performance measures, and the inclusion of students' external frames of reference. Certain issues not addressed could be included in future research. It would be of interest to include internal frames of reference (see Introduction) in a future study, as these may attenuate or inflate domain-specific self-beliefs (Möller et al., 2009; Möller et al., 2011; Skaalvik & Skaalvik, 2002). Research that includes both frames of reference could complement other work investigating these issues in early tracking systems (e.g., Möller et al., 2009; Möller et al., 2011). Also, mathematics self-concept was not measured in Grade 6. Given that Grade 9 self-efficacy did not contribute to the mediation model in the presence of Grade 9 mathematics self-concept, it would be of interest to isolate the effects of self-efficacy in Grade 6 when a concurrent measure of mathematics self-concept is included.

#### **Acknowledgements**

The authors thank the creators of the COOL<sup>5-18</sup> (2007/8) and (2010/11) datasets for the use of the datasets, and Greetje van der Werf and Hans Kuypers from GION, Institute for Educational Research, University of Groningen for the use of supplementary data. The datasets were obtained from the Data Archiving Network Services (DANS) website (<http://www.dans.knaw.nl>) with references:

COOL<sup>5-18</sup> (2007/8):

- SCO-Kohnstamm Instituut Amsterdam; ITS Radboud Universiteit Nijmegen; CITO Arnhem; GION RU Groningen
- Cohortonderzoek Onderwijsloopbanen van 5-18 jaar - COOL 5-18 - Basisonderwijs 2007; Eerste meting basisonderwijs 2007 (2007-09-01, 2008-04-30)
- Persistent identifier: urn:nbn:nl:ui:13-icz-r75

## CHAPTER 8

COOL<sup>5-18</sup> (2010/11):

- GION RU Groningen, CITO Arnhem, SCO-Kohnstamm Instituut Amsterdam, ITS Radboud Universiteit Nijmegen
- Cohortonderzoek Onderwijsloopbanen van 5-18 jaar - COOL 5-18 - Voortgezet Onderwijs Klas 3 - 2010/11 (2012-11-09)
- Persistent identifier: urn:nbn:nl:ui:13-y9jp-e0