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**Predicting Change Across and After the Transition to High School: A Longitudinal Path Analytic
Examination of Math-Related Beliefs and Values**

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Predicting Change Across and After the Transition to High School: A Longitudinal
Path Analytic Examination of Math-Related Beliefs and Values

Tracy Abarbanel

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*This dissertation is dedicated to my mother, Linda Abarbanel, who is and has
always been my rock*

and

*to my father-in-law, Len Fluet, whose commitment and support to our family has
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Abstract

Effects of the transition to high school on students' beliefs and attitudes about mathematics were investigated in the present longitudinal study. The influence of students' math grades, competence beliefs, and values before making the transition, as well as changes in these beliefs and values across the transition, on their math grades and enrolment intentions were examined across Grades 8, 9, and 10. Based on the theoretical framework of Eccles and colleagues' model of achievement (Wigfield & Eccles, 2000), two path analytic models were tested for boys and girls separately on data collected from the same students across Grades 8, 9, and 10 ($n_s = 290, 265, \text{ and } 249$ for boys; $311, 278, \text{ and } 255$ for girls, respectively). Short-term effects were assessed on students' math grades and math enrolment intentions in Grade 9 (Model 1) and longer-term effects on these same variables in Grade 10 (Model 2). On average, students as a group showed declines in their math competence beliefs, their perceived usefulness and intrinsic valuing (boys only) of math, and in their math grades across the three years. Conversely, students' math enrolment intentions increased across this same period. Changes in stability were only found for boys' math utility value (increase) and girls' math competence beliefs (decrease). Results of path analyses indicated that, across both models, changes in math competence beliefs directly predicted boys and girls' math grades and girls' math enrolment intentions, beyond the direct effects of their math competence beliefs in Grade 8 (e.g., before making the transition to high school). Changes in math values predicted directly students' math enrolment intentions, also beyond the effects of their values for math in Grade 8 (before the transition). Although there were many similarities in the Models across gender, some noteworthy differences in the continuity of and relations between these variables for boys

and girls' are discussed. In both models, changes in math competence beliefs predicted directly changes in math values across the same time periods. Results of Model 1 supported a direction of causality from math competence beliefs to math values. Results of Model 2 were inconclusive in this regard. This study has provided support for the key relations between math grades and math-related competence beliefs, values, and enrolment intentions. It has also extended previous research by examining empirically the influence of actual changes that are occurring in students' math competence beliefs and values for math across and after the transition to high school.

INTRODUCTION

Among the noted declines associated with the transition to high school, researchers have pointed to the significance of the changes students experience in their achievement-related competence beliefs and values. As mathematics is fundamental to many academic and career-related options, it has been identified as an important subject area within which to examine the changes that are occurring in students' ability beliefs and values across the transition to high school. Furthermore, because it has typically been considered a more masculine subject area, the potential for gender differences in the declines associated with the transition to high school may be greater in math than in other academic domains.

As proximal predictors of math achievement and math enrolment intentions, students' perceptions of their math ability and the values they hold for math are important variables to examine across the transition to high school. Although declines in math competence beliefs and values are well documented (Fredricks, & Eccles, 2002; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002), there exists some variability as to their onset, magnitude, and gender specificity. Also, inferences about the negative effects of these declines have been drawn based on the associations between low levels of competence beliefs and values and poor academic achievement and low enrolment intentions. There is a dearth of empirical research assessing the link between the actual measured changes in competence beliefs and values across the transition to high school and their influence on students' achievement-related outcomes.

The focus of the present study is on the nature and effects of the changes students experience in their math competence beliefs and values for math across and after the transition to high school. In order to examine the nature of the changes that are occurring

during this period, in Part 1 we examined mean-level changes and stability correlations as measures of the continuity of students' math-related competence beliefs, values, performance, and enrolment intentions across Grades 8, 9, and 10. In Parts 2 and 3, path analytic models were tested separately by gender to assess the short and longer-term effects of the changes in math competence beliefs and values for math (from Grades 8 to 9 and 9 to 10) on students' subsequent math performance and math enrolment intentions.

In the sections below, past theoretical and empirical investigations are presented as they relate to the subject area of math and to the timeframe within which students make the transition to senior high school.

Transition to High School

Researchers have described adolescence as a developmental period characterized by multiple changes in many different areas (Eccles, Midgley, Wigfield, Buchanan, Reuman, Flanagan, & MacIver, 1993). In addition to numerous physical changes associated with puberty, adolescent youth are also faced with adjustments to increasing emotional independence, more mature peer relationships, and the salience of preparing for future educational and occupational careers (Jaffe, 1998). In terms of preparing for their future, it is during adolescence that many youth begin making their very first academic choices (e.g., course selection) – choices that may limit their future educational and occupational options.

As with most other developmental age periods, changes in adolescence occur at both the internal and external levels. In addition to internal factors, including adolescents' physical, cognitive, and emotional development, environmental factors play a key role in perpetuating change. Educational environments have been considered an important external

factor associated with change and adjustment in adolescence, particularly as students spend a great deal of time at school.

School transitions are central to many of the changes and adjustments occurring throughout the adolescent years, particularly as they often co-occur with other developmental tasks (e.g., physical and social changes). Although variability exists in the frequency of school transitions, the majority of students experience at least one in their adolescent years (Otis, Grouzet, & Pelletier, 2005). The commonality of the transition to high school, coupled with its short and sometimes longer-term disruption, has led researchers to identify it as an important developmental period in which to examine change.

Within the academic domain, researchers have noted a negative trend in a number of achievement-related variables throughout early and middle adolescence. In particular, during the transitions to junior and senior high school, declines have been observed in students' achievement-related performance (Seidman, LaRue, Aber, & Mitchell, 1994), self-perceptions of ability and values (Watt, 2004), interest in school and motivation (Akos & Galassi, 2004), perceived teacher support (Barber & Olsen, 2004), and self-esteem (Cantin & Boivin, 2004). Simmons and Blyth (1987) have found that the magnitude of the decline students experience in their academic performance is predictive of subsequent academic failure and school dropout. Although declines have been identified in many different areas, the negative changes in achievement-related performance, competence beliefs, and values noted throughout the adolescent years, and particularly across educational transitions, have not been found consistently. Specifically, the observed negative trend appears to vary according to the academic domain one considers.

Different explanations have been proposed for the noted declines in some areas of student academic functioning, attitudes, and motivation during the early and middle adolescent years. The contributing role of stress due to multiple co-occurring changes, as well as factors within the educational system (e.g., classroom organization, educational practices, and evaluation criteria) and their fit with youth's developmental needs, have all been factors implicated in the various negative changes associated with the transition to high school.

Co-occurring Change

Some researchers have attributed the negative changes associated with the transition to high school to stress, given the multiple co-occurring changes that students experience at this time in their lives (e.g., Akos & Galassi, 2004; Seidman, LaRue, Aber, Mitchell & Feinman, 1994). According to this view, a temporary drop in academic performance and achievement-related beliefs will occur as adolescents attempt to cope with the accumulation of stress due to the many changes occurring for them at this point in their development. In terms of external factors, the educational environment has been considered of central importance to change and adjustment in adolescence. Among the changes associated with the educational environment across the transition into high school, the size of the school and classroom, the role of teachers from elementary to high school, and the shift to a more performance-based evaluation criteria have all been implicated in the negative changes experienced by students at this time. Taken together, researchers believe that the individual developments combined with school changes are numerous, co-occurring, and disruptive during the early- to mid-adolescent years.

Stage-environment Fit

Within a developmental framework, Eccles and Midgley (1989) have suggested that the aforementioned noted declines may be explained by changes in the nature of the learning environment that coincide with students' developmental needs as they make the transition from elementary to junior and senior high school. They argue that changes in classroom organization, task structure, grouping practices, and evaluation techniques, among others, may be developmentally inappropriate. In other words, it has been suggested that there exists a mismatch between aspects of the high school classroom environment and the developing needs of middle adolescent students (Barber & Olsen, 2004). For example, the organizational curriculum in most North American high schools centers primarily on practices that promote competitiveness and comparative performance evaluations (Maehr & Midgley, 1996) at a time when adolescents are more self-conscious and self-focused (Harter, 1990). There are fewer opportunities for joint-decision making (MacIver & Reuman, 1988) at a time of increased need for autonomy and when adolescents desire more control. A more stringent grading criteria leading to decreased grades is implemented at a time when adolescent females' self-perceptions of their ability are one of the strongest predictors of their future performance and enrolment intentions (Crombie, Sinclair, Silverthorn, Byrne, DuBois, & Trineer, 2005; Eccles & Midgley, 1989; Finger & Silverman, 1996). From this perspective, changes in the academic learning environment from elementary to high school have negative effects on students' adaptation and functioning because of their poor fit with the developing needs of adolescents at this time. Given the sometimes conflicting concurrence of educational changes and developmental needs, the transition to high school is an important period in which to examine changes

experienced by adolescents and the influence of these changes on achievement-related outcomes and adjustment.

Effects of the Transition as a Function of Gender, Academic Domain,
and their Interaction

Gender

In looking at the effects of the transition to high school, some researchers have reported gender difference in students' experience of and adaptation to this period. For example, it has been suggested that girls, as compared to boys, experience greater distress (Blyth, Simmons, & Carlton-Ford, 1983; Eccles, Midgley, Wigfield, Miller, Buchanan, Reuman, Flanagan, MacIver, 1993) and report more concerns in general around the transition to high school period (Diemert, 1992). Females in this latter study also endorsed more concerns around social and academic issues than did their male counterparts (Diemert, 1992). Other researchers have found that, over the transition period, girls demonstrate a greater drop in self-esteem (Eccles et al., 1993) and experience greater depression (Hirsch & Rapkin, 1983) than do boys. In terms of feelings of connectedness to school, Akos and Galassi (2004) found gender differences in how boys and girls experience the transition from elementary to middle school as compared to the transition from middle school to high school. Specifically, girls reported feeling more connected to their middle school but less connected to their high school than did boys. By way of explanation, the researchers suggested that peer upheaval and psychological distress during this time may be more pronounced for girls than for boys. In contrast to the above findings, Seidman and colleagues (1994) reported no gender differences in the declines in self-esteem and global academic performance associated with the transition to high school. Wampler, Munsch,

and Adams (2002) also found no differential outcome of the transition to high school in terms of academic performance based on gender.

The variability of results concerning gender differences in the effects of the transition to high school may be explained partially by the context in which girls and boys are compared. Within an achievement framework, researchers have noted that students experience differential effects of the transition to high school based on the academic domain in question. The focus of the present study is on the academic domain of math. Given its centrality to many academic programs and occupational careers, it is important to investigate factors that may affect students in this area.

Academic Domain

Despite the general picture of negative effects associated with the transition to high school, differences exist according to academic domain. Specifically, negative changes in achievement-related performance, competence beliefs, values, interests, and motivation noted throughout the adolescent years, and particularly across educational transitions, have not been found consistently in all subject matters. Studies examining age differences in students' competence beliefs in the subject domains of math and English have yielded somewhat different results. For math, general declines in students' self-perceptions of their ability have been found to occur through the junior and senior high school years. For English, adolescents' perceptions of their ability were higher and more positive than those of younger elementary school children (Eccles et al., 1983; Marsh, 1989). With respect to task values, early adolescents' values for math and sports have been found to decrease, whereas their value for English remained stable during middle school and later on increased (Eccles et al., 1983; Marsh, 1989). Also, researchers have found declines in

students' academic intrinsic motivation with age for math, science, and reading, but not for social studies (Gottfried, Fleming, & Allen, 2001).

Gender x Academic Domain Interaction

The combination of gender and academic domain differences in students' experience of the transition to high school emerge in part through their perceptions of the school environment (Bong, 2005) and of subject-specific classroom settings (Urdan & Midgley, 2003). Transition studies have found that there is a shift in students' perceptions of their learning environments from a mastery goal orientation to a more performance-based goal orientation as they move from elementary to junior and senior high school (Bong, 2005; Urdan & Midgley, 2003), and that the effects of such perceptions are different based on the specificity of the context in question (Urdan & Midgley, 2003).

Although performance goal structures have typically been associated with maladaptive motivational behaviours, such as avoidance and self-handicapping strategies (Turner, Meyer, Midgley, & Patrick, 2003), researchers have found that achievement-related outcomes depend in part on the fit between students' perceptions of their learning environment and their approach to schoolwork (e.g., Bong, 2005). However, it has also been suggested that students' views of their classroom environment affect their own approach to learning, such that perceptions of a mastery-based setting will prompt more mastery-oriented learning and perceptions of a performance-based environment will elicit the adoption of a more performance-based learning strategies (Church, Elliot, & Gable, 2001; Roeser, Midgley, & Urdan, 1996).

Interestingly, the converging of students' learning approaches to perceptions of their academic environment has not been found when it comes to the subject area of

mathematics. For example, in her study with Korean high school girls, Bong (2005) found that, despite perceptions of a reduced mastery focus and more performance-based learning environment in high school, girls' neither increased their use of performance-approach goals nor reduced their personal mastery orientation when it came to math. Urdan and Midgley (2003) found that when middle-school students perceived their academic environment as performance based, they increased their personal performance goals at the general school level. However, when it came to their learning approach to math, no increases in performance goals were associated with the same performance-based perceptions.

With girls holding more mastery approaches to learning than boys, it has been suggested that the more competitive environments of stereotypically masculine fields, such as math, may not be as good of a fit for girls as for boys (Cross & Vick, 2001; Griffin-Pierson, 1988; Hayden & Holloway, 1985). Because of the salience of math for future academic pursuits, this misfit has been found to affect girls' later aspirations and career choices (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006). As such, math has been identified as an important subject area in which to examine gender differences in the changes (and their effects) associated with the transition to high school.

Math

With an increase in reliance on math, science, and technology-related fields, the Canadian and U.S. markets will continually be in demand of persons educated in such disciplines. Despite a narrowing in the gender gap in high school math enrolment (Wirt, Choy, Rooney, Provasnick, Sen, & Tobin, 2004), there exists a decline in the number of women pursuing educational degrees and careers in math (Panteli, Stack, & Ramsay,

2001). Men also continue to earn more graduate degrees in math than do women (Wirt et al., 2004). Whereas English is considered a general subject matter that is fundamental to many occupations, math and science are identified as related to more specific occupations. Researchers have defined math as a critical filter for adolescents' future options (Hyde, Fennema, Ryan, Frost, & Hopp, 1990). Decisions of whether or not to take higher-level math courses become critical in high school, as it is during this period that students make their initial choice regarding their involvement in the math stream. It is possible that the negative changes students experience in their math-related performance, beliefs, and values across the transition to high school would lead to drops in their math enrolment intentions at the very point when they are faced with decisions about their math involvement. For example, researchers have found that math enrolment intentions are predicted directly by math grades for boys (Crombie et al., 2005; Eccles, 1984) and by math competence beliefs for girls (Crombie et al., 2005; Ethington, 1991). Adolescence, therefore, is a significant period in which to examine changes in performance, self-perceptions of ability, and task values for math, as these, in turn, will affect students' math-related decisions and behaviour.

Supporters of the gender-intensification theory believe that gender-role socialization will lead to increases in gender differences in math, particularly during adolescence, when pubertal changes are likely to fuel existing gender-role socialization practices (Eccles et al., 1987; Hill & Lynch, 1983). Other researchers, however, believe that the gender gap in math competence beliefs will decrease over time (Ruble & Martin, 1998), as social pressures promoting gender egalitarianism will enable girls to hold more equal views to boys (Hyde et al., 1990). Notwithstanding predictions about the future of the

gender gap in mathematics, researchers continue to report gender differences in students' math-related achievement, competence beliefs, and values.

Gender differences in math performance are mixed. Some researchers suggest that girls outperform boys in high school math (Dwyer & Johnson, 1997). Others have found that males fare better than their female counterparts in advanced level math courses at the high school and college levels (Hyde, Fennema, & Lamon, 1990). Still others report no gender differences in math grades among youth who are not of European descent. For example, in their meta-analysis, Hyde et al. (1990) found no gender differences in math performance among African Americans, Hispanic Americans, or Asian Americans. Notwithstanding these varying results in math performance, and even when girls do outperform boys in math, research has shown that girls hold lower self-perceptions of their math ability than do boys (Crombie et al., 2005; Fredricks & Eccles, 2002; Herbert & Stipek, 2005).

In addition to lower perceptions of math competence, researchers have found that adolescent females also hold lower performance expectations in math than do males (Eccles, 1987; Stipek & Gralinski, 1991). For example, in their research with junior high school students, Stipek and Gralinski (1991) found that females not only rated their math ability lower than did males, they also had lower expectations in terms of their future success in math. With respect to values for math, there is some research to suggest that adolescent boys report greater intrinsic value for math (Hyde et al., 1990; Hyde, Fennema, et al., 1990) and hold a higher utility value for math (Eccles, 1983) than do girls. Given the associations between girls' math competence beliefs and values for math and their future math performance and math enrolment intentions (Crombie et al., 2005; Simpkins et al.,

2006), the need to examine gender differences in students' math-related beliefs and values remains important.

Society's increased reliance on math, science, and technological disciplines and women's under-representation in math professions reveal the importance of investigating factors that are predictive of girls' performance and involvement in math. Given the associations between math competence beliefs, math performance, and math enrolment intentions, the fact that girls continue to hold lower self-perceptions of their math ability than do boys, even in the face of superior math performance, delineates the need to investigate factors that are important to math achievement and math enrolment for boys and girls separately.

Expectancy-Value Model of Achievement

Eccles and her colleagues (Eccles et al., 1983; Eccles, Wigfield, & Schiefele, 1998) have developed a model of achievement in which the causal effects of various social and psychological factors are hypothesized in the prediction of achievement-related behaviours and choices. The model is thus composed of a socialization component and psychological component. In the socialization component, factors such as parents' and teachers' beliefs about a child/student's ability, parents' and teachers' support, and cultural norms are some of the variables hypothesized to influence students' own competence beliefs and values. It is suggested that students' respective interpretations of these social interactions and experiences mediate their effect on achievement-related outcomes and choices, hence the connection to the psychological component of the model. According to psychological or expectancy-value component of their larger model, the major cognitive determinants of achievement related outcomes, such as grades and educational and occupational choices,

include individuals' competence beliefs and their subjective task values. These variables are hypothesized as key constructs because they have a direct influence on achievement-related behaviours and mediate the influence of other constructs, such as prior academic achievement and the various social constructs identified above. Negative changes in students' competence beliefs and values across and after the transition to high school have been considered noteworthy, given that these constructs are the most proximal predictors of achievement-related behaviours and choices in the Eccles' model.

Competence Beliefs

According to Eccles and colleagues, competence beliefs (self-perceptions of ability) are defined as "the assessment of one's own competency to perform specific tasks or to carry out role-appropriate behaviours" (Eccles et al., 1983, p.82). As such, they refer to an individual's belief about his or her skill in a certain area and ability to do well at a given task (Durik et al., 2006). According to the model, feeling competent in one's ability is predictive of achievement-related performance (Wigfield & Eccles, 2000). The association between competence beliefs and success in achievement contexts has also been identified in other social cognitive theories (e.g., Bandura, 1997, 1999; Lent, Brown, & Hackett, 1994; Steele, 1997). Specifically, in addition to predicting academic performance, competence beliefs have also been associated with effort, persistence, cognitive engagement, and motivation (Bandura, 1994; Eccles et al., 1998; Schunk, 1991).

Consistent with the model of Eccles and colleagues, several researchers have provided support for the predictive relation between competence beliefs and academic performance (Crombie et al., 2005; Marsch & Yeung, 1998; Valentine et al., 2004). In their recent meta-analytic review of the relation between beliefs and academic achievement,

Valentine and his colleagues, concluded that self-beliefs consistently predict academic achievement, even after controlling for initial levels of achievement (Valentine et al., 2004). As well, they reported that the estimated effect size of the relation between beliefs and academic achievement, which was small at the general level, is stronger when measured for specific domains (e.g., math or science). Feather (1988) also found that the association between competence beliefs and achievement-related performance varies as a function of academic domain.

There are several reasons why math has been identified as an important subject area within which to examine relations between math competence beliefs and other key components of Eccles' model, including values, achievement, and enrolment intentions. First, it has been suggested that performance and intrinsic values are more influenced by ability in the area of math than in other subjects, such as English (Eccles, 1984). When Stodolsky and colleagues asked children to cite examples of when they liked math and Social Studies, students reported liking math when they perceived it as not being difficult for them. Their liking of Social Studies on the other hand was more strongly associated with their interest in the topic being taught (Stodolsky, Salk, & Glaessner, 1991). Second, gender differences favouring boys in competence beliefs have been reasonably consistent for math but not always for other academic domains. In a study of Grade 8 students who had comparable math grades, Catsambis found that girls not only held lower math competence beliefs than did their male counterparts, but were also less likely to identify math as a key part of their career aspirations in Grade 10 (Catsambis, 1999). The fact that girls underestimate their math ability as compared to boys is a finding that is generally well established in the literature (Heller & Ziegler, 1996; Juang & Silbereisen, 2002). Third,

because math has typically been considered a male-stereotyped subject as compared to English or Social Studies, examining the relations between competence beliefs, values, performance and choices for boys and girls separately is important in this particular subject domain. Finally, despite a proliferation of research supporting the predictive relation between math competence beliefs and math performance, more recent studies have found that math competence beliefs are also predictive of girls' math enrolment intentions (Crombie et al., 2005; Simpkins et al., 2006). Decisions adolescents make in high school, regarding their enrolment in upper or standard level math courses or about whether or not to remain in the math stream, play a critical role in what educational and occupational options will be available to them. As such, examining the expectancy-value component of Eccles' larger model of achievement at a time when adolescents are beginning to make decisions about their future involvement in math is developmentally relevant.

Task Values

One of Eccles' most important contributions to the field of achievement involves her elaboration of the task values component of the expectancy-value model. Specifically, she defined four related but distinct aspects of task values: attainment value, intrinsic value, utility value, and cost (Eccles et al., 1983). Attainment value refers to the perceived importance of doing well on a task. It is the value one places on good performance (Feather, 1988). Intrinsic value is defined as individuals' subjective interests in a particular subject, or how enjoyable it is to them (Deci & Ryan, 1985; Harter, 1981). Utility value is how useful a subject is perceived to be relative to the individual's future goals. These goals can either be short- or long-term in nature (Eccles [Parsons] et al., 1983). Lastly, cost is conceptualized as the cumulative negative aspects of undertaking a particular task.

It is believed that children's early conceptions of task values may be confounded with their interest in a particular activity and that it is not until adolescence that students understand more clearly the usefulness of different academic subjects for their future educational and occupational goals. In other words, children's cognitive development plays a significant role in their emerging values. Researchers have noted that young children's conceptions of task values differ from those of older children and adults in that they are more global and less differentiated (Meece, Wigfield, & Eccles, 1990). For example, whereas young children's task values are largely determined by their intrinsic value in a particular subject (Wigfield & Eccles, 1992), adolescents' perceived usefulness of a subject area is expected to play a more significant role in their valuing of a subject. Thus, because adolescents have more systematic and differentiated conceptions of task values than do younger children, and begin making enrolment decisions at this stage in their education, adolescence is an appropriate timeframe within which to examine the influence of the various components of task values (e.g., students' intrinsic and utility value). Based on these considerations, the focus of the present study was on adolescents' utility and intrinsic values for math as two individual components of their math task values. Given the stronger emphasis on utility value during adolescence, we included a path from changes in students' utility value for math to changes in their intrinsic values for math experience in both models.

As with competence beliefs, and in addition to age differences, conceptions of task values are also influenced by subject domain. In other words, there exists domain by age differences in students' task values. In their research with elementary school-aged children, Wigfield and colleagues used a cohort-sequential longitudinal design to assess mean-level

changes in children's task values for different subject areas, including math, reading, music, and sports (Wigfield et al., 1997). Their results support the depiction of different developmental trajectories for children's task values according to subject domain. Specifically, they found that children's intrinsic value varied more by subject domain than did their ratings of the usefulness/ importance of subjects. They found that, across Grades 3 to 6, the strongest decrease in students' intrinsic value occurred for music and reading, whereas decreases in children's intrinsic value for math and sports were less pronounced. With adolescents, however, Eccles and her colleagues found that students' global values for math and sports decreased significantly, whereas their valuing of English remained stable and, over time, actually increased (Eccles et al., 1989).

Specific to the subject area of mathematics, researchers have found that the value students place on math shows a general decrease from Grades 1 to 12 (Fredricks & Eccles, 2002; Jacobs & Eccles, 2002) and that the declines in their perceived usefulness and importance of math in junior high school continue into high school and are then accompanied by a decrease in their intrinsic values for math (Eccles, 1984; Wigfield et al., 1991). It is believed that declines in youth's intrinsic values for math begin during the transition to high school (Eccles, 1984; Wigfield et al., 1991).

Results of gender differences in students' math task values, however, are mixed. There is some research to suggest that adolescent boys report greater intrinsic value for math (Hyde et al., 1990; Hyde, Fennema et al., 1990) and hold a higher utility value for math (Eccles, 1983) than do girls. Other researchers have found that boys and girls report similar values for math (Andre, Whigham, Hendrickson, & Chambers, 1999; Jacobs et al., 2002; Simpkins et al., 2006).

With respect to the predictive influence of math values, results vary depending on whether global measures of task values versus the various components of math values are employed. In earlier studies in which math task values were found to predict math enrolment intentions (Eccles et al., 1983; Ethington, 1991) or actual math enrolment (Eccles, 1984), global measures of task values were used (e.g., some combination of intrinsic and utility/importance values). More recently, the varying components of task values for math and their influence on students' math choices have been examined. For example, some researchers have found that students' intrinsic values for math and the value they place on the usefulness of math both predict their math enrolment intentions (e.g., Atwater, Wiggins, & Gardner, 1995; Meece, Wigfield, & Eccles, 1990). Others have found that students' utility value for math, and not their intrinsic value, was most predictive of their math enrolment intentions (Crombie et al., 2005).

With respect to the prediction of actual math enrolment, researchers have emphasized the significance of students' intrinsic values and perceptions of the usefulness of math (Joyce & Farenga, 2000; McGuire, McHale, & Updegraff, 1996). Interestingly, in a recent study examining the longitudinal link between math beliefs and choices, Simpkins and colleagues found that students' intrinsic values, but not their perceived usefulness of math, predicted their actual math enrolment in high school (Simpkins et al., 2006). Based on these mixed results, although math values are predictive of youth's choices regarding their math involvement, continuing research is needed to examine more carefully the differential influence of the different components of task values for math. In the present study, the differential predictive effect of students' utility and intrinsic values for math on their math enrolment intentions will be examined separately for boys and girls.

Direction of Causality between Math Competence Beliefs and Values for Math

Researchers, including both Eccles and Bandura in their respective research areas, have predicted that adolescents' task values for math are influenced by their self-perceptions of their math ability (Bandura, 1997, Eccles et al., 1983). Lopez and colleagues found that, in terms of task values, high school students' (mean age = 15 years old) intrinsic values for math were predicted by their self-perceptions of their math ability (Lopez, Lent, Brown, & Gore, 1997). Based on these considerations, it is believed that the direction of causality runs from math competence beliefs to values for math. By way of explanation, it has been suggested that students come to value those tasks (or subjects) at which they believe they are competent. Conversely, students may lower their values when they do not believe they are competent at a given task.

In recent studies, researchers have stressed the importance and need to further assess the longitudinal associations between math competence beliefs and values for math in order to determine the causal order of their relations (Simpkins et al., 2006; Wigfield & Eccles, 2000). Knowing about a general direction of causality becomes important when contemplating intervention and prevention efforts. Specifically, if the direction of causality does run from math competence beliefs to values for math, then efforts that help students develop higher perceptions of their math ability will likely have a similar positive effect on their values for math. In the present study, the direction of causality between the constructs of math competence beliefs and values for math was tested within a longitudinal model of change.

Negative Change across the Transition to High School: Effects of Declines in Math Competence Beliefs and Values for Math

Given the occurrence of negative changes in math competence beliefs and values for math across the transition to high school, it is important to examine not only the association between these variables, but also the predictive influence of the actual declines themselves. Based on the established associations between math competence beliefs and math achievement, it has been deduced that negative changes in math competence beliefs predict negative changes in math performance. Similarly, inferences about the influence of the negative changes in students' valuing of math on their math enrolment intentions have been made on the basis of the relation between math task values and math enrolment intentions. As such, concerns about the negative changes occurring in students' math competence beliefs and values for math across the transition to high school center largely on the inferred influence of these negative changes on students' future math achievement and enrolment intentions. Whereas there are reasonable theoretical grounds on which to suggest such an association, to our knowledge, there are no studies to date that have assessed empirically the influence of the actual negative changes that are occurring in students' math competence beliefs and values for math across the transition to high school. Specifically, no research has incorporated measures of intra-individual changes in math competence beliefs and values across the transition to high school and then assessed the influence of these change variables on students' subsequent math performance and math enrolment intentions. In the present study, we examine the predictive effects of changes in students' math competence beliefs and values for math (utility and intrinsic) across the

transition to high school on their math performance and math enrolment intentions in Grade 9.

Measurement of Change

With respect to the analysis of longitudinal data, there has been much debate in the social and behavioural sciences about the comparative validity of change scores.

Traditionally, simple difference scores (also called gain scores) were most often employed in longitudinal research as measures of change. However, during the past several decades, scientists have criticized their use for several reasons. The criticisms, cited by Maxwell and Delaney (1990) and in the works of other researchers (Williams & Zimmerman, 1982), center predominantly around the psychometric properties of such change scores. Simple difference scores have been said to be biased estimates of true change such that, under certain circumstances, they do not show individual differences in true change. For example, on data sets where Time 1 (or the initial score) and Time 2 (final score) scores are highly correlated and demonstrate relatively equal variances, simple difference scores reveal growth curves that are parallel and therefore reveal no individual differences in change. As such, simple gain scores have been shown to have low reliability under certain conditions related to the correlation of pre- and post-test measures.

Concerns around the use of simple difference scores have led researchers and psychometricians to adopt the use of alternative measures of change. The most widely used of the proposed alternatives is the residual difference score (e.g., Heggstad & Kanfer, 2005; Williams et al., 1984). In contrast to simple difference scores that have been criticized for their low reliability and correlation with the initial score, residual difference

scores are preferred because the post-test change score excludes all variance that could have been linearly predicted from the pre-test status (Gottman & Krokoff, 1990).

By way of addressing the criticisms around the use of simple difference scores, Rogosa (1988) notes that the claims of unreliability in the analysis of gain scores only hold true under very particular situations and that, under many other circumstances, simple gain scores offer an equally accurate interpretation of change as do residual change scores. For example, he notes that when the Time 1- Time 2 correlation is moderate and the variances at Time 1 and Time 2 differ, gain scores show decent reliability. As such, he argues that outside of certain very specific and unlikely conditions, the use of residual change scores does not offer a significantly superior level of reliability to the simple difference score.

Williams and Zimmerman (1982) state that the superior reliability of gain or residual change scores varies as a function of the correlation between the pretest and posttest measures. To address the admonitions of psychometricians, they developed a simple rule for when to use the simple difference score versus the residual difference score. Within their article they refer to the term λ , which is the ratio of the standard deviations of the Time 1 scores and the Time 2 scores (the standard deviation of the Time 1 scores divided by the standard deviation of the Time 2 scores). Accordingly, they note that if the correlation of the Time 1 scores and the Time 2 scores is greater than the value of λ , then the use of the simple difference scores is suggested. If that condition is not met, then the use of the residual difference scores has been suggested as the superior method of computing and interpreting true change.

In keeping with this general rule-of-thumb and based on the value of the correlation of our Time 1 and Time 2 scores relative to the value of lambda, residual difference scores were used in the present study.

Summary of Research to Date

Although most researchers acknowledge a negative developmental trend in students' math competence beliefs, values for values, math performance, and math enrolment intentions across the transition to high school, there exists some variability in (1) the magnitude and continuity of these negative changes across different academic domains, (2) gender differences in these noted declines in the area of math, and (3) the longer-term effects of such changes on boys and girls' math-related outcomes. A significant limitation of existing research in this area has been the absence of studies examining the influence of the actual changes that are occurring in math competence beliefs and values for math across the transition to high school. To date, conclusions about the predictive effects of negative changes associated with the transition to high school have been based on the association between low levels of one variable with low levels of another variable. For example, it has been suggested that since competence beliefs predict performance, then negative changes in these beliefs will in turn produce negative changes in performance. Few studies have assessed the influence of actual changes that students experience across the transition to high school. Given that achievement-related beliefs and values have been identified as principal determinants of behaviour, choices, and success in achievement contexts (Stipek, 1992), an assessment of the short- and longer term effects of this negative trend is important. Furthermore, gender-stereotypes that have historically led to the perception of math as a male-gendered subject, as well as gender differences favouring

males in math competence beliefs, underlie the importance of examining at the relation among these variables separately for males and females.

Purpose

The present study consisted of three main objectives. In Part 1, the central goal was to assess the continuity of math-related competence beliefs, values, performance, and enrolment intentions across and after the transition to high school (Grades 8, 9, and 10). As such, mean-level changes and stability correlations were used to derive a developmental trajectory of the magnitude and nature of the changes that are occurring in these variables across and after the transition to high school. In Parts 2 and 3, the main objectives were to (1) assess the direction of causality between the constructs of math competence beliefs and values for math, (2) provide support for key relations between math competence beliefs, values for math, math performance, and math enrolment intentions outlined in Eccles' expectancy-value model, and (3) examine the differential predictive influences of changes in math competence beliefs and values for math across and after the transition to high school on adolescents' short- and longer-term math performance and math enrolment intentions. Using residual scores as measures of intra-individual change, Parts 2 and 3 of the current study are a first time examination of the role of change (in math competence beliefs and values for math) in predicting adolescents' math performance and math enrolment intentions across and after the transition to high school.

Part 1

One of the benefits of examining achievement-related beliefs and values, and academic-related performance and choices within a developmental and longitudinal framework is that it permits us to examine trends in mean-level changes and assess the

stability of intra-individual change across time. With respect to group stability, mean-level changes provide us with important information about the magnitude and direction of how each variable mean changes across time. Because mean-level changes are useful in delineating changes in the absolute level of these constructs over time, but not in providing information about change at the individual level, stability correlations are an important complimentary measure of continuity. As measures of change at the individual level, stability correlations reveal the cross-time stability of an individual's position within a group (Gottfried et al., 2001; Lightfoot & Folds-Bennett, 1992). From such results, we are able to predict a student's position relative to a larger group across time. Specifically, results of stability correlations will inform us about whether students who begin at the lower, middle, or higher ends of the group on a particular variable (e.g., math competence beliefs) will remain in similar positions relative to the larger group over time.

In Part 1, mean-level changes and stability correlations of math competence beliefs, values for math, math performance and math enrolment intentions were evaluated on data collected from the same students over three years (Grades 8, 9 and 10). Taken together, results of these two measures, change and stability, provide a picture of the continuity of each variable across and after the transition to high school.

Hypotheses

The following hypotheses concern mean-level changes in students' math competence beliefs, values for math (utility and intrinsic values), math performance, and math enrolment intentions.

- (1) Consistent with the results of existing studies, math competence beliefs were expected to become increasingly negative across and after the transition to high

school (from Grades 8 to 9 to 10), such that mean-levels were hypothesized to be lower in Grade 9 than in Grade 8, and lower in Grade 10 than in Grade 9. Also consistent with the literature, boys were expected to have higher math competence beliefs than girls across the three years.

- (2) Given the positive association between adolescents' beliefs and values, students' utility and intrinsic values for math were also hypothesized to decrease across and after the transition to high school. Specifically, mean-level decreases in students' utility and intrinsic values for math were hypothesized to be lower in Grade 9 than in Grade 8, and lower in Grade 10 than in Grade 9. As reported in previous research, we expected boys to have a higher utility value for math than girls across the three years.
- (3) With students having to adapt to a more stringent grading system from elementary school to high school, we expected that the drop in math performance from Grades 8 to 9 would be more pronounced than the drop from Grades 9 to 10. As reported in previous research, we expected girls to have a higher math grades than boys across the three years.
- (4) Given the positive association between values for math and math enrolment intentions, we hypothesized that adolescents' math enrolment intentions would also decrease across Grades 8, 9, and 10.

The following hypotheses pertained to the cross-time stability of students' competence beliefs, values for math, math performance, and math enrolment intentions:

- (1) As predicted by Eccles and her colleagues, adolescents' math competence beliefs and values for math were expected to become more stable with age. As such, the

correlation values of math competence beliefs from Grades 9 to 10 would be higher than those from Grades 8 to 9.

- (2) Again, given the positive association between beliefs and values, students' utility and intrinsic values for math from Grades 9 to 10 were expected to become increasingly stable across the three years. As such, the correlation values of the two math values for math from Grades 9 to 10 would be higher than those from Grades 8 to 9.
- (3) Adolescents' math grades were expected to become increasingly stable after the transition to high school. With the need to adjust to a different and more stringent grading system as students make the transition to high school, we expected that the correlation of math grades from Grades 8 to 9 would be lower than from Grades 9 to 10.
- (4) We predicted that adolescents' math enrolment intentions would become less stable across and after the transition to high school. With the novelty of course selection beginning in Grade 10, we expected there would be a period of decreased stability in students' math enrolment intentions. As such, we hypothesized that the correlation of intentions from Grades 9 to 10 would be lower than that from Grades 8 to 9.

Part 2

The general purpose of Part 2 was to examine a proposed model of achievement (Model 1) in which the predictive influence of changes in math competence beliefs and values for math were examined across the transition to high school (Grades 8 to 9). Within this short-term longitudinal model, three major components were examined: (1) The

direction of causality between math competence beliefs and values for math, (2) The relations between adolescents' pre-transition Grade 8 math grades, math competence beliefs and values for math in the prediction of their Grade 9 math performance and math enrolment intentions, and (3) The influence of changes in students' math competence beliefs and values for math from Grades 8 to 9 on their Grade 9 math performance and math enrolment intentions. Figures 1 and 2 illustrate Model 1 conceptually for boys and girls, respectively.

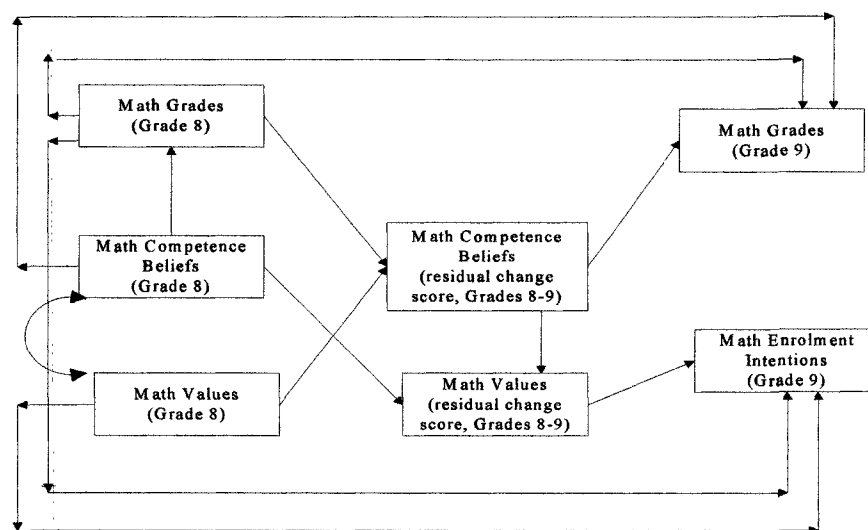


Figure 1. Hypothesized longitudinal model for adolescent boys from Grades 8 to 9.

Note. For simplicity, and at the conceptual level only, utility and intrinsic values for math are denoted as a single variable.

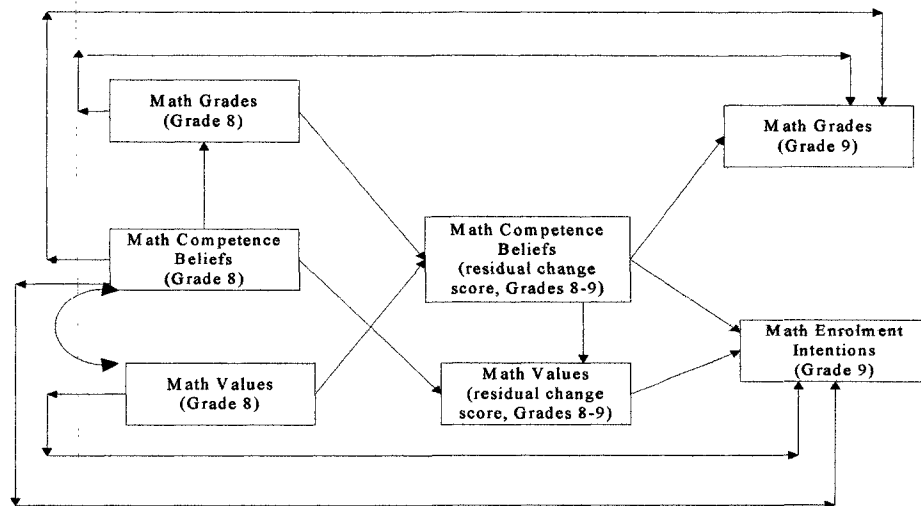


Figure 2. Hypothesized longitudinal model for adolescent girls from Grades 8 to 9.

Note. For simplicity, and at the conceptual level only, utility and intrinsic values for math are denoted as a single variable.

Math Competence Beliefs and Values for Math: Direction of causality

Based upon the theoretical work of Wigfield and Eccles (2000), one goal of Part 2 was to examine, within a longitudinal framework, the causal order of the relation between students' math competence beliefs and task values for math. Consistent with Eccles and colleagues' theoretical model (Wigfield & Eccles, 2002), competence beliefs in math (Grade 8) were hypothesized to predict changes in students' task values for math overtime (residual change score for task values for math from Grades 8 to 9). As a plausible alternative, we also considered the converse. Specifically, we incorporated into the model the path estimate reflecting the causal association from math task values (Grade 8) to changes in math competence beliefs overtime (residual change score for math competence beliefs from Grades 8 to 9). The purpose of examining the significance of these two path estimates was to determine the causal order of the relations among math competence

beliefs and the two task values for math (utility and intrinsic) within a longitudinal framework.

Hypothesized Direct Effects

The following estimated paths were hypothesized based on Eccles and colleagues' theoretical framework, in addition to results of previous cross-sectional and longitudinal studies conducted within the framework of this achievement model.

From Grade 8 math grades. Students' math grades in Grade 8 were hypothesized to predict directly their Grade 9 math performance (grades). They were also hypothesized to predict math enrolment intentions in Grade 9 directly for boys, but not for girls. Finally, Grade 8 math grades were expected to predict directly changes in students' math competence beliefs from Grades 8 to 9 (residual change score for math competence beliefs, Grades 8 to 9).

From Grade 8 math competence beliefs. Students' math competence beliefs in Grade 8 were hypothesized to predict directly their Grade 8 and Grade 9 math performance. They were also hypothesized to predict math enrolment intentions in Grade 9 directly for girls, but not for boys. Consistent with the hypothesized direction of causality from ability-related beliefs to task values, we expected that Grade 8 math competence beliefs would predict directly changes in their values for math from Grades 8 to 9 (residual change scores for utility and intrinsic values for math, Grades 8 to 9).

From Grade 8 values for math. Students' utility and intrinsic values for math in Grade 8 were expected to predict directly their Grade 9 math enrolment intentions. In order to test the direction of causality between math competence beliefs and values for math, paths were also tested from the two Grade 8 task values for math (utility and intrinsic) to

changes in math competence beliefs from Grades 8 to 9 (residual change score, Grades 8 to 9).

From changes in math competence beliefs. Changes in students' math competence beliefs from Grades 8 to 9 (residual change score, Grades 8 to 9) were hypothesized to predict directly both boys and girls' Grade 9 math grades and girls' Grade 9 math enrolment intentions. Consistent with a hypothesized direction of causality from beliefs to values, changes in students' math competence beliefs from Grades 8 to 9 were expected to predict directly changes in both of their values for math from Grades 8 to 9 (residual change scores for utility and intrinsic values for math, Grades 8 to 9). We did not include paths from changes in the two math values to changes in math competence beliefs from Grades 8 to 9 because we were not testing specifically the direction of causality between these change variables in the model. In the present study, the testing of the direction of causality between math competence beliefs and values for math was tested between the Grade 8 variables and the residual change score variables (see paths from Grade 8 math competence beliefs and values for math).

From changes in values for math. Changes in the two values for math from Grades 8 to 9 (residual change scores, Grades 8 to 9) were expected to predict directly students' Grade 9 math enrolment intentions. As utility value becomes more salient during adolescence, changes in students' utility value for math from Grades 8 to 9 (residual change score, Grades 8 to 9) were hypothesized to predict changes in their intrinsic valuing of math across this same period (residual score, Grades 8 to 9). This path is not reflected in the hypothesized models in Figures 1 and 2 due to the conceptual collapsing of utility and intrinsic values for math under the umbrella term of "values for math".

Hypothesized Indirect Effects

In addition to the hypothesized direct paths outlined above, Model 1 includes several important indirect effects.

Consistent with the assumption that students' math competence beliefs predict changes in their task values for math, the primary hypothesis with respect to direction of causality was that students' math competence beliefs in Grade 8 would indirectly affect their math enrolment intentions in Grade 9 via their effect on changes in their task values for math from Grades 8 to 9 (residual change scores for utility and intrinsic values for math, Grades 8 to 9). However, in keeping with the possibility that the predominant direction of causality may be from students' task values for math to changes in their math competence beliefs, we also considered an alternative indirect effect. Specifically, we tested a secondary hypothesis that students' values for math in Grade 8 would indirectly effect their math grades in Grade 9 via their effect on changes in their math competence beliefs from Grades 8 to 9 (residual change score, Grades 8 to 9).

In terms of other indirect effects, students' Grade 8 math grades were expected to predict their Grade 9 math grades not only directly, but also indirectly through changes in their math competence beliefs from Grades 8 to 9 (residual change score, Grades 8 to 9). For girls, it was hypothesized that their Grade 8 math grades would have an indirect effect on their Grade 9 math enrolment intentions via changes in their math competence beliefs from Grades 8 to 9 (residual change score, Grades 8 to 9).

Hypothesized Gender Differences

- (1) Based on the results of prior research, we hypothesized a direct path from Grade 8 math grades to Grade 9 math enrolment intentions for boys but not for girls. We

expected that the models, reflecting this gender difference, would fit the data well for boys and girls, respectfully.

- (2) Based on the results of prior research, we hypothesized direct paths from Grade 8 math competence beliefs to Grade 9 math enrolment intentions, as well as from changes in math competence beliefs from Grades 8 to 9 to Grade 9 math enrolment intentions for girls, but not for boys. We expected that the models, reflecting this gender difference, would fit the data well for boys and girls, respectively.

Part 3

The purpose of Part 3 was to examine the longer-term effects of the transition to high school on adolescents' math-related beliefs, values, performance, and choices. Whereas in Part 2 we examined the influence of changes in math competence beliefs and values for math across the transition to high school (from Grades 8 to 9), Part 3 concerned the influence of changes in these same variables in the year after the transition to high school (from Grades 9 to 10).

Three major components were examined: (1) The direction of causality between math competence beliefs and values for math, (2) The relations between adolescents' pre-transition Grade 8 math grades, math competence beliefs and values for math in the prediction of their Grade 10 math performance and math enrolment intentions, and (3) The influence of changes in students' math competence beliefs and values for math from Grades 9 to 10 on their Grade 10 math performance and math enrolment intentions. Figures 3 and 4 illustrate Model 2 conceptually for boys and girls, respectively.

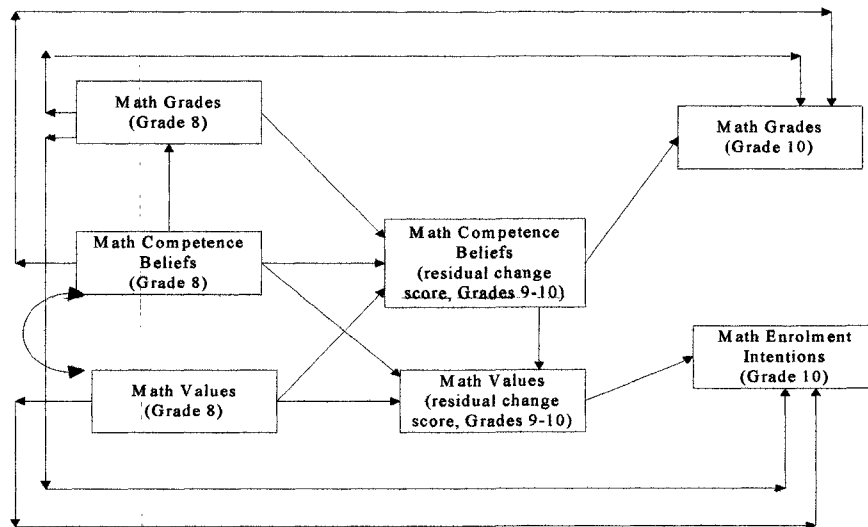


Figure 3. Hypothesized longitudinal model for adolescent boys from Grades 8 to 10.

Note. For simplicity, and at the conceptual level only, utility and intrinsic values for math are denoted as a single variable.

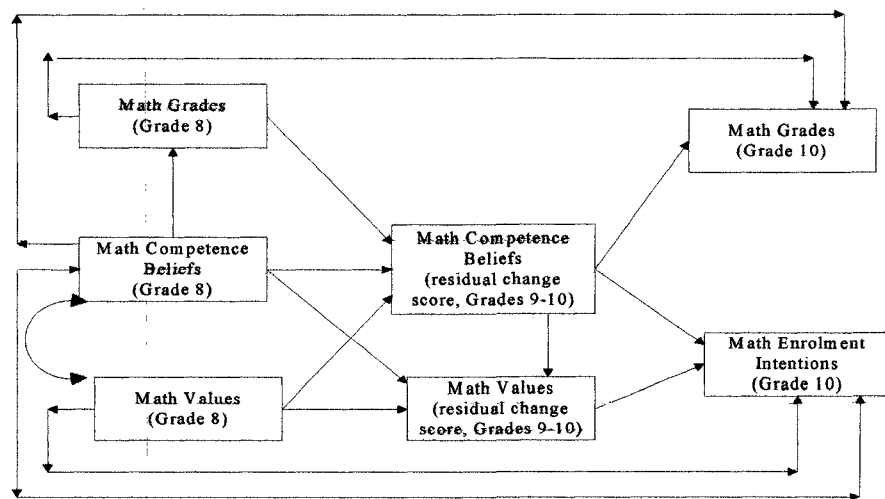


Figure 4. Hypothesized longitudinal model for adolescent girls from Grades 8 to 10.

Note. For simplicity, and at the conceptual level only, utility and intrinsic values for math are denoted as a single variable.

Math Competence Beliefs and Values for Math: Direction of Causality

As in Part 2, one goal of Part 3 was to determine, within a longitudinal framework, the causal order of the relation between students' math competence beliefs and task values for math. Based on prior research, our main hypothesis was that math competence beliefs (Grade 8) would predict changes in students' task values for math overtime (residual change score for task values for math from Grades 9 to 10). As a secondary, less likely hypothesis, we also considered the converse. Specifically, we incorporated into the model the path estimate reflecting the causal association from math task values (Grade 8) to changes in math competence beliefs overtime (residual change score for math competence beliefs from Grades 9 to 10). The purpose of examining the significance of these two path estimates in Model 2 was to provide additional support to our Model 1 results for the direction of causality between math competence beliefs and the two task values for math (utility and intrinsic) within a longitudinal framework.

Hypothesized Direct Effects

The following estimated paths were hypothesized based on Eccles and colleagues' theoretical framework, in addition to results of previous cross-sectional and longitudinal studies conducted within the framework of this achievement model.

From Grade 8 math grades. Students' math grades in Grade 8 were hypothesized to predict directly their Grade 10 math performance (grades). They were also hypothesized to predict math enrolment intentions in Grade 10 directly for boys, but not for girls. Finally, Grade 8 math grades were expected to predict directly changes in students' math competence beliefs from Grades 9 to 10 (residual change score for math competence beliefs, Grades 9 to 10).

From Grade 8 math competence beliefs. Students' math competence beliefs in Grade 8 were hypothesized to predict directly their Grade 8 and Grade 10 math performance (grades). They were also hypothesized to predict math enrolment intentions in Grade 10 directly for girls, but not for boys. Grade 8 math competence beliefs were expected to predict directly changes in math competence beliefs from Grades 9 to 10. Finally, consistent with the hypothesized direction of causality from to values, we expected that Grade 8 math competence beliefs would predict directly changes in their values for math from Grades 9 to 10 (residual change scores for utility and intrinsic values for math, Grades 9 to 10).

From Grade 8 values for math. Students' utility and intrinsic values for math in Grade 8 were expected to predict directly their Grade 10 math enrolment intentions. They were also expected to predict directly changes in the two math values from Grades 9 to 10. Finally, in order to test the direction of causality between math competence beliefs and values for math, paths were also tested from the two Grade 8 task values for math (utility and intrinsic) to changes in math competence beliefs from Grades 9 to 10 (residual change score, Grades 9 to 10).

From changes in math competence beliefs. Changes in students' math competence beliefs from Grades 9 to 10 (residual change score, Grades 9 to 10) were hypothesized to predict directly both boys and girls' Grade 10 math grades and girls' Grade 10 math enrolment intentions. Consistent with a hypothesized direction of causality from beliefs to values, changes in students' math competence beliefs from Grades 9 to 10 were expected to predict directly changes in both of their values for math from Grades 9 to 10 (residual change scores for utility and intrinsic values for math, Grades 9 to 10).

From changes in values for math. Changes in the two values for math from Grades 9 to 10 (residual change scores, Grades 9 to 10) were expected to predict directly students' Grade 10 math enrolment intentions. As students begin making choices regarding their math enrolment in Grade 10, their perceptions of the usefulness of math were expected to become more influential than were their intrinsic values for math. As such, changes in adolescents' utility value for math from Grades 9 to 10 would be a stronger predictor of Grade 10 math enrolment intentions than would be changes in their intrinsic valuing of math over this same period.

Changes in students' utility value for math from Grades 9 to 10 (residual change score, Grades 9 to 10) were also hypothesized to predict changes in their intrinsic valuing of math across this same period (residual score, Grades 9 to 10). This path is not reflected in the hypothesized models in Figures 3 and 4 due to the conceptual collapsing of utility and intrinsic values for math under the umbrella term of "values for math".

Hypothesized Indirect Effects

In addition to the hypothesized direct paths outlined above, Model 2 includes several important indirect effects.

Consistent with the assumption that students' math competence beliefs predict changes in their task values for math, the primary hypothesis with respect to direction of causality was that students' math competence beliefs in Grade 8 would indirectly affect their math enrolment intentions in Grade 10 via their effect on changes in their task values for math from Grades 9 to 10 (residual change scores for utility and intrinsic values for math, Grades 9 to 10). However, in keeping with the possibility that the predominant direction of causality may be from students' task values for math to changes in their math

competence beliefs, we also considered an alternative indirect effect. Specifically, we tested a secondary hypothesis that student values for math in Grade 8 would indirectly affect their math grades in Grade 10 via their effect on changes in their math competence beliefs from Grades 9 to 10 (residual change score, Grades 9 to 10).

In terms of other indirect effects, students' Grade 8 math grades were expected to predict their Grade 10 math grades not only directly, but also indirectly through changes in their math competence beliefs from Grades 9 to 10 (residual change score, Grades 9 to 10). For girls, it was hypothesized that their Grade 8 math grades would have an indirect effect on their Grade 10 math enrolment intentions via changes in their math competence beliefs from Grades 9 to 10 (residual change score, Grades 9 to 10).

Hypothesized Gender Differences

- (1) Based on the results of prior research, we hypothesized a direct path from Grade 8 math grades to Grade 10 math enrolment intentions for boys, but not for girls. We expected that the models, reflecting this gender difference, would fit the data well for boys and girls, respectively.
- (2) We hypothesized direct paths from Grade 8 math competence beliefs to Grade 10 math enrolment intentions, as well as from changes in math competence beliefs from Grades 9 to 10 to Grade 10 math enrolment intentions for girls, but not for boys. We expected that the models, reflecting this gender difference, would fit the data well for boys and girls, respectively.

METHOD

Participants

The sample for the present study included participants spanning three years (Grades 8, 9, and 10) of a larger longitudinal study of Canadian adolescents. Grade 8 students were recruited from six public elementary schools and followed in 11 different public high schools centered in and around a mid-sized Canadian city. The schools were in three middle SES and primarily European-Canadian school districts, serving urban, suburban, and adjacent small towns. Exclusion criteria for the study were:

- (1) Enrolment in a special education program (indicating reading comprehension levels significantly below that of same-age peers).
- (2) Recent immigration, if there was evidence of a language barrier affecting reading comprehension.

In terms of consent forms, the average return rate by class was 60%, with a range between 22% and 87% among classes. The initial sample size of youth who met inclusion criteria consisted of 601 Grade 8 students, broken down by gender as follows: 290 male students and 311 female students. With attrition rates of 9 % in Grade 9 and 7.5 % in Grade 10, resulting sample sizes were 547 and 506 students in Grades 9 and 10, respectively. These samples were broken down by gender as follows: In Grade 9, 268 male and 279 female students participated in the study. In Grade 10, the sample consisted of 249 male and 257 female students. The primary reasons for attrition were relocating out of the area or having moved to non-participating schools, as well as time conflicts in students' availability to complete the questionnaires in the time slots allotted by the schools. After removing four students who were multivariate outliers in Grade 9 and two in Grade 10, the

final sample for the current investigation consisted of 601 students (290 boys and 311 girls) in Grade 8, 543 students (265 boys and 278 girls) in Grade 9, and 504 students (249 boys and 255 girls) in Grade 10.

Data were collected from parents of 86% of the youth in our sample. Most of the adolescent students were from English speaking two parent families. Reports from participating parents indicated that 75% of them were born in Canada and 90% spoke English. The majority of participants' fathers worked as professionals (45%) or in technical positions (29%). With respect to participants' mothers, approximately 18% held professional positions, 27% technical-level positions, and 14% identified their occupation as homemakers. These data were based on the Blishen Socioeconomic Index for Occupations, a Canadian socioeconomic index (Blishen, Carroll, & Moore, 1987),

Procedure

A proposal for the present study was submitted to and approved by the University of Ottawa's ethics committee. Over the course of the present research project, treatment of all participants was in accordance with the ethical standards of the Canadian Psychological Association. Following the university's approval, an overview of the present study was submitted to the Carleton Board of Education. The project was approved and the board of education subsequently generated a list of available high schools that, if willing, could participate in the study. From this list, each school principal was sent a letter describing the proposed study. These letters were followed up one week later by a telephone call through which the primary researcher addressed any concerns on the part of the school principals. Of the 11 elementary schools that were included on the list of available schools generated by the Board of Education, six agreed to participate in the present study. The remaining

schools did not consent to participate as they reported current involvement in another research project. Having obtained consent by the principals, staff from each school generated a list of Grade 8 students. A letter describing the study and requesting parental consent was sent to the students' parents or guardians. Whereas parental consent for their child's participation in the study was obtained by written consent, students provided verbal consent to participate in the study. Students were also informed that the study was not related to their evaluation at school and that they could withdraw at any time without penalization. Thus, consent for participation in the present study was obtained at the level of the school boards and individual schools, from the parents or guardians of the students involved in the study, as well as from the students themselves.

Once consent was obtained at each level, scheduling of data collection with each school was arranged in a manner designed to minimize disruption of regular classes. Each year (Grade 8, 9, and 10), students completed two questionnaires in the months of April and May. This timeframe ensured that they had completed approximately 80 % of their academic year. The questionnaires were administered in a classroom setting to allow students to work in a familiar environment. Trained research staff with predetermined instructions administered the questionnaires to small groups of 10 to 25 students in two separate 45-minute sessions, approximately one month apart. Two shorter sessions, as opposed to one longer one, were held to enable students to stay on task. Administration instructions were given verbally at the beginning of each questionnaire session and were audio recorded to assess consistency. Students were informed that their responses were confidential and would not be communicated to their parents or to school personnel.

In a third and separate session, research staff selected at random two to three students per group and asked them to complete an identical questionnaire to the one they had already completed. This information was used to calculate test-retest reliability on a random sample of our larger student sample. These students were reminded that they were not obliged to complete this measure for a second time and were free to refuse without penalty.

Finally, at the end of each school year, and with the participants' consent, the school was asked to provide the primary researcher with a photocopy of each student's grades in the subject domains of interest (e.g., math).

Measures

The data used for the present study are only a portion of the total data that were collected from the participants. Only the measures relevant to the current study are presented.

Adolescent Questionnaire

All students completed a questionnaire that was designed to assess a number of different constructs regarding students' academic beliefs, values, and educational and occupational plans in varying subject areas (math, science, and English). The key constructs in the present study included students' math competence beliefs, their perceptions of the usefulness of and intrinsic value for math, and their math enrolment intentions.

The items for the various scales in the questionnaire were adopted from the Student Attitude Questionnaire (SAQ) developed by Eccles and her colleagues to assess children and adolescents' beliefs about various social and academic activities (Eccles, 1984; Eccles,

1983). Many of the factor-derived scales have been used in previous studies (e.g., Frome & Eccles, 1998; Jacobs, 1991; Wigfield et al., 1997; Wigfield & Eccles, 2002), and their psychometric properties (reliability, construct validity, predictive validity, and face validity) are well established (Eccles, 1983; Parsons et al., 1982; Wigfield & Eccles, 2002).

Measures of each of the constructs in the present study were selected for the following reasons:

- (1) The present study is based on the Expectancy-Value Model of Achievement. Thus, using similar measures (as in previous studies) to test the model will facilitate the comparison of results.
- (2) The psychometric properties (e.g., reliability and validity) of the measures used to test the model have been well established.
- (3) Eccles and her colleagues have tested parts of the Expectancy-Value model with adolescents and have thus provided age- and gender psychometric results. Given the developmental changes in some of these constructs, it is important to employ suitable measures with age- and gender-fitting psychometric information.

Each of the different constructs included in the present study were assessed using a 7-point Likert-type scale anchored at each extreme with short verbal descriptors. Examples of the numeric anchors are (1) = "Not at All Good", "Not at All Useful", and "A Little" and (7) = "Very Good", "Very Useful", and "A Lot". To facilitate a comparison of the scales, composite scores were calculated for each scale by summing the item scores and dividing by the number of items in the scale.

Math competence beliefs. Four items were used to assess adolescents' math competence beliefs. These items assess the degree to which students' believe they are good

at math, the degree to which they believe they are good at math relative to other school subjects, the degree to which they believe they are good at math relative to other students in their class, and their beliefs about how well they predict they will do in math in the current year. The specific four items that measured math competence beliefs were: "How good at math are you?" (1 = Not Very Good, 7 = Very Good), "Compared to most of your other school subjects, how good are you at math?" (1 = Much Worse, 7 = Much Better), "If you were to rank all the students in your math class from the worst to the best in math, where would you put yourself?" (1 = The Worst, 7 = The Best), and "How well do you think you will do in math this year?" (1 = Not at all Well, 7 = Very Well).

These items were initially developed by Parsons et al. (1980) and are reported in Jacobs and Eccles (1992). They have been employed in numerous other studies as well (e.g., Crombie et al., 2005; Jacobs & Eccles, 1992; Parsons et al., 1980; Simpkins et al., 2006; Wigfield et al., 1997). Moderately high internal consistency (median α s = .84 - .94) for this scale has been reported in a number of studies (Eccles et al., 1984; Fuligni, Eccles, & Barber, 1995; Jacobs & Eccles, 1992; Meece et al., 1990; Parsons, Adler, & Kaczala, 1982). In the present study, internal consistency for this scale was obtained for male and female participants (α s of .92 and .90 in Grade 8, respectively; .93 and .92 in Grade 9, respectively, and .93 and .92 in Grade 10, respectively.) On a sub-set of 62 of the Grade 9 students in the present study, one-month test-retest reliability was found to be respectably high ($r = .91$).

Utility value. Students' utility value or their perceptions of the usefulness of math were assessed using four items from Parsons et al.'s (1980) original five-item importance/usefulness scale. The four items reflect students' perceptions of how generally

useful is the math they are learning, how useful they think it is for when they graduate and for their future employment, and how useful is high school math. Specific items were: “In general, how useful is what you learn in math?” (1 = Not at all Useful, 7 = Very Useful), “How useful do you think the math you are learning will be for what you want to do after you graduate and go to work?” (1 = Not at all Useful, 7 = Very Useful), “Is math this year worthwhile to you?” (1 = Not at all Worthwhile, 7 = Very Worthwhile), and “How useful do you think high school math will be for what you want to do after you graduate and go to work?” (1 = Not at all Useful, 7 = Very Useful).

In Grades 8, 9, and 10 of the present study, high internal consistency was obtained for this scale for both boys (α s = .91, .88, and .83, respectively) and girls (α s = .89, .88, and .86, respectively). One-month test-retest reliability on a sub-set of 62 of the Grade 9 students was found to be moderately high (α = .76).

Intrinsic value. Students’ intrinsic values for math were assessed using two of the four items initially developed by Parsons et al (1980). These two items, used recently by other researchers in the measurement of students’ intrinsic value (Eccles & Wigfield, 1995; Fuligni et al., 1995; Simpkins et al., 2006), assess how much students like doing math and whether they find working on math assignments boring or interesting. Specific items were, “How much do you like doing math?” (1 = A Little, 7 = A Lot), and “In general, I find working on math assignments ...” (1 = Very Boring, 7 = Very Interesting). Researchers have reported moderate to high internal consistency values for this two-item scale (α = .88 for females, α = .84 for males, and α s = .76 - .91 for combined samples) for this subscale (Eccles et al., 1995; Fuligni et al., 1995). For the present study, internal consistency measures for boys and girls were equal to α s of .88 and .89 in Grade 8, respectively and .89

and .90 in Grade 10, respectively. One-month test-retest reliability on a sub-set of 62 of these Grade 9 students was also found to be moderately high ($\alpha = .84$).

Enrolment intentions. Adolescents' intentions to enroll in future math courses were measured by one item in which they are asked whether they will take more math when they are no longer required to. The specific item was, "Will you take more math when you don't have to?", with a response format ranging from 1 = very definitely will not take more to 7 = very definitely will take more. Previous researchers (e.g., Eccles & Jacobs, 1986; Meece et al., 1990) examining adolescents' intentions to enroll in future mathematics courses have used this same item. One-month test-retest reliability on this measure is respectably high ($r = .80$) for a sub- set of 62 Grade 9 students from the current sample.

Academic Grades. Students' Grade 8, 9, and 10 report cards were obtained and math grades were used as a measure of their math performance. With participants' consent, their grades were obtained from school records for each of the four terms or two semesters in the each academic year. As scores of several indicators are a more valid representation of a construct than are scores from only one indicator variable, grades from two time points were used. For students in non-semestered schools, second term marks in January and fourth term marks in June were considered. For students in semestered schools, both marks from the semester in which they took math were used in the present study.

RESULTS

The data analyses for the present research project were completed in four general steps. Findings of the preliminary analyses are presented first. Subsequent results are presented in three sections. In Part 1, mean-level changes and variable stability are reported for math-related competence beliefs, values, performance, and enrolment intentions as students move from Grades 8 to 9. In Part 2, path analysis results for Model 1 are presented. This model is based on Grades 8 and 9 data and represents the year in which students make the transition to high school. Part 3 involves the path analysis results for Model 2, which extends Model 1 to include the year after the transition to high school (Grades 8, 9 and 10).

Preliminary Analyses

Variables in the proposed models included math grades, math competence beliefs, utility and intrinsic values for math, and math enrolment intentions. Each of these variables was measured at three different points in time; Grades 8, 9, and 10 (Time1, Time2, and Time3, respectively).

The assumptions of univariate and multivariate normality and linearity were evaluated using SPSS FREQUENCIES and REGRESSION (SPSS 13, 2004; Tabachnick & Fidell, 1996, 2001). With respect to the assumption of univariate normality, model variables that were significantly nonnormally distributed were math utility value at Grade 8 and Grade 9 measurement points, and math enrolment intentions at Grade 9 and Grade 10 measurement points. As a result of these four significant non-normal distributions, robust maximum-likelihood estimation and the Satorra-Bentler scaled chi-square were used for all path analysis models. Within each path model estimation, the standard errors associated with the

parameter estimates were also adjusted for the extent of nonnormality (Satorra & Bentler, 1988). The distribution of univariate (scores more than three standard deviations from the sample mean) and multivariate outliers was examined. Twelve univariate outliers out of 601 cases were detected, representing less than 1% of the data set. The influence of univariate outliers was minimized by reducing the 12 values of interest to three standard deviations from the mean (see Tabachnick & Fidell, 2001). With the use of $p < .001$ criterion for Mahalanobis distance, a total of six multivariate outliers were detected and hence removed from the analyses. Following the removal of the six students who were multivariate outliers, the resulting sample sizes for the three years of data included in this study were 601 (boys = 290; girls = 311), 543 (boys = 265; girls = 278) and 504 (boys = 249; girls = 255), respectively.

Part 1: Mean-level Changes, Gender Differences, and Variable Stability

Mean-level Changes

In Part 1, four hypotheses concerned mean-level changes in students' math competence beliefs, values for math, math performance, and math enrolment intentions across the three time measurement points, two of which concerned gender differences in these mean-level changes. Means and standard deviations for all model variables as a function of time are reported in Table 1 for the combined sample, as well as for boys and girls separately.

Table 1

Descriptive Statistics for Model Variables

Variable	<u>Time 1</u>		<u>Time 2</u>		<u>Time 3</u>	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Combined Sample						
	<i>(n = 601)</i>		<i>(n = 543)</i>		<i>(n = 504)</i>	
Grades	77.00	13.06	71.65	14.67	70.44	15.46
Comp beliefs	5.19	1.22	5.04	1.31	4.80	1.46
Ut value	5.53	1.22	5.34	1.29	5.07	1.46
Int value	4.43	1.64	4.23	1.62	4.09	1.74
Enr intentions	5.00	1.59	5.56	1.63	5.80	1.59
Boys						
	<i>(n = 290)</i>		<i>(n = 265)</i>		<i>(n = 249)</i>	
Grades	75.00	13.35	70.84	15.28	69.30	15.64
Comp beliefs	5.42	1.10	5.24	1.26	4.91	1.47
Ut value	5.59	1.20	5.30	1.26	5.03	1.48
Int value	4.52	1.60	4.28	1.56	3.98	1.72
Enr intentions	4.98	1.67	5.40	1.69	5.60	1.70
Girls						
	<i>(n = 311)</i>		<i>(n = 278)</i>		<i>(n = 255)</i>	
Grades	79.00	12.48	72.45	14.03	71.58	15.23
Comp beliefs	4.96	1.30	4.85	1.34	4.70	1.45
Ut value	5.47	1.25	5.38	1.33	5.10	1.44
Int value	4.34	1.68	4.18	1.68	4.20	1.76
Enr intentions	5.01	1.50	5.71	1.55	5.98	1.45

Note. With the exception of Grades, the range of scores for each variable is 1-7. Comp beliefs = math competence beliefs; Ut value = math utility value; Int value = math intrinsic value; Enr intentions; math enrolment intentions.

To evaluate the hypothesized group differences, a 3 (time) x 2 (gender) repeated measures analysis of variance (ANOVA) was run in SPSS for each of the following model variables: Math grades, math competence beliefs, utility value for math, intrinsic value for math, and math enrolment intentions. Thus, incorporating all model variables, a total of five repeated measures ANOVAs were run to evaluate group differences as a function of time and gender (see Appendixes E to I for *F* values). The assumption of sphericity was violated in all five of these analyses. Therefore, results for the multivariate *F*s are reported with the Greenhouse-Geiser correction for degrees of freedom.

(1) It was hypothesized that adolescents' math competence beliefs would become increasingly negative across Grades 8, 9, and 10. Results of the 3 x 2 ANOVA indicate that there were significant main effects of both time, $F(2, 502) = 22.79, p < .05$, and gender, $F(1, 502) = 13.68, p < .001$. With respect to the main effect of time and consistent with our hypothesis, Scheffé post hoc tests indicated that students reported significantly decreasing levels of math competence beliefs across Grades 8, 9, and 10 ($M_s = 5.19, 5.04, 4.80$, respectively). Also consistent with our hypothesis, results of the significant main effect of gender indicated that boys reported higher levels of math competence belief than did girls across Grades 8, 9, and 10.

(2) It was hypothesized that adolescents' utility and intrinsic values for math would become increasingly negative across Grades 8, 9, and 10. Results of the 3 x 2 ANOVA indicate that there was significant main effect of time, $F(2, 502) = 28.58, p < .01$, but not of gender. With respect to the main effect of time and consistent with our hypothesis, Scheffé post hoc tests indicated that students reported significantly decreasing levels of utility value for math across Grades 8, 9, and 10 ($M_s = 5.53, 5.34, 5.07$, respectively). In

terms of gender differences, results did not support our hypothesis that male students would have a higher utility value for math than would female students.

Similar to utility value, students' intrinsic value for math was expected to decrease across the three years of data. Results of the 3 x 2 repeated measures ANOVA indicate that there was a significant time x gender interaction effect, $F(2, 502) = 4.61, p < .01$. This significant interaction effect was followed by an evaluation of the simple effects of time across the two levels of gender. Results indicate that, for girls, there was no significant mean-level decrease in their reported intrinsic values for math across the three Grades ($M_s = 4.34, 4.18, \text{ and } 4.20$ for Grades 8, 9, and 10, respectively). Consistent with our hypothesis, adolescent boys in our sample reported significantly decreasing levels of math intrinsic value across and after the transition to high school ($M_s = 4.52, 4.28, \text{ and } 3.98$ for Grades 8, 9, and 10, respectively).

(3) The third hypothesis concerned students' academic grades for math. We expected that the drop in students' math grades from Grades 8 to 9 would be more pronounced than the drop in their math grades from Grades 9 to 10. Results of the 3 x 2 repeated measures ANOVA indicated that there were significant main effects of both time, $F(2, 502) = 73.47, p < .001$, and gender, $F(1, 502) = 6.01, p < .05$. With respect to a main effect of time and consistent with our hypothesis, Scheffé post hoc tests indicated that students math grades decreased significantly from Grades 8 to 9 ($M_s = 77.00 \text{ and } 71.65$, respectively), but not from Grades 9 to 10 ($M = 70.44$ in Grade 10). As hypothesized, results of the significant effect of gender indicated that girls obtained higher math grades than did boys across Grades 8, 9, and 10.

(4) Lastly, adolescents' math enrolment intentions were hypothesized to decrease across the three years of data. Results of the 3 x 2 repeated measures ANOVA indicated that there were significant main effects of both time, $F(2, 502) = 54.65, p < .001$, and gender, $F(1, 502) = 4.67, p < .05$. With respect to the main effect of time, the results did not support our hypothesis. Scheffé post hoc tests indicated that students' math enrolment intentions increased significantly across the three years. Specifically, the increase in adolescents' math enrolment intentions was more pronounced from Grades 8 to 9 ($M_s = 5.00$ and 5.40 , respectively) than it was from Grades 9 to 10 ($M = 5.60$ in Grade 10). With respect to the main effect of gender, results indicated that girls had significantly higher math enrolment intentions than did boys across and after the transition to high school.

Variable Stability

Four hypotheses in Part 1 concerned the stability of the variables across time. Pearson correlation coefficients were calculated to determine the stability of these variables across Grades 8, 9, and 10. Pearson correlations between all variables in Model 1 (Grades 8 to 9) are presented in Table 2. Table 3 represents correlations between variables from Grades 9 to 10 (see Appendix A for correlations between variables from Grades 8 to 10).

(1) In Hypothesis 1, we predicted that adolescents' math competence beliefs and values for math would become increasingly stable over the three years, such that the variable correlations from Grades 9 to 10 (Time 2 to Time 3) would be higher than those from Grades 8 to 9 (Time 1 to Time 2). Results varied as a function of gender. Adolescent boys showed no increase in the stability of their math competence beliefs across Grades 8, 9 and 10. Specifically, the correlation value from Grades 8 to 9 ($r_1 = .63$) did not differ significantly from their Grades 9 to 10 correlation ($r_2 = .54$). For girls, however, there was a

significant difference in the magnitude of the correlation values of their math competence beliefs across time ($p < .05$) ($r_1 = .65$; $r_2 = .45$) Contrary to what we hypothesized, girls' math competence beliefs became less stable as they moved through the transition year and into the post-transition year (across Grades 8, 9 and 10).

(2) The pattern of results for math utility value also varied as a function of gender. As predicted, boys' utility value for math increased in stability after the transition to high school, such that the correlation coefficient from Grades 9 to 10 ($r_2 = .66$) was significantly higher than it was from Grades 8 to 9 ($r_1 = .50$) ($p < .05$). Adolescent girls in our sample showed no significant difference in the stability of their math utility value across this same time period ($r_1 = .53$, $r_2 = .61$). With respect to students' intrinsic value for math, no differences in the stability across the three years was found for either boys ($r_1 = .52$; $r_2 = .61$) or girls ($r_1 = .58$; $r_2 = .63$).

(3) We hypothesized that adolescents' math grades would increase in stability across the three time measurement points, such that the variable correlations from Grades 9 to 10 (Time 2 to Time 3) would be higher than those from Grades 8 to 9 (Time 1 to Time 2). This hypothesis was not supported. For both male and female subjects, the correlation coefficients of math grades from Grades 8 to 9 ($r_1 = .67$; $r_1 = .62$, respectively) did not differ significantly from those from Grades 9 to 10 ($r_2 = .64$; $r_2 = .55$, respectively). Therefore, there was no increase in the stability of students' math grades across and after the transition to high school.

(4) In the third hypothesis, we predicted that adolescents' math enrolment intentions would decrease in stability across Grades 8, 9, and 10. As such, it was hypothesized that the correlation of math enrolment intentions from Grades 9 to 10 would be lower than this

same variable correlation from Grades 8 to 9. Results did not support this hypothesis. For both boys and girls, the correlation of math enrolment intentions from Grades 8 to 9 ($r_1 = .41$; $r_1 = .39$, respectively) did not differ significantly from the Grades 9 to 10 correlation ($r_2 = .52$; $r_2 = .39$, respectively). Thus, there was no decrease in the stability of adolescents' math enrolment intentions after the transition to high school.

Table 2

Model 1: Intercorrelations Between Grades 8 and 9 Variables as a function of Gender

Measure	1	2	3	4	5	6	7	8	9	10
1. Grades (T1)	--	.67**	.64**	.54**	.12	.20**	.25**	.31**	.26**	.38**
2. Grades (T2)	.62**	--	.60**	.76**	.13*	.29**	.19**	.40**	.22**	.35**
3. Comp beliefs (T1)	.66**	.50**	--	.63**	.29**	.28**	.51**	.43**	.35**	.35**
4. Comp beliefs (T2)	.56**	.72**	.65**	--	.18*	.46**	.28**	.59**	.29**	.39**
5. Ut value (T1)	.26**	.21**	.45**	.33**	--	.50**	.57**	.39**	.41**	.20**
6. Ut value (T2)	.20**	.28**	.30**	.45**	.53**	--	.36**	.69**	.37**	.49**
7. Int value (T1)	.41**	.31**	.65**	.41**	.55**	.37**	--	.52**	.36**	.24**
8. Int value (T2)	.35**	.46**	.50**	.65**	.31**	.57**	.58**	--	.41**	.45**
9. Enr intentions (T1)	.29**	.20**	.41**	.21**	.47**	.28**	.45**	.30**	--	.41**
10. Enr intentions (T2)	.21**	.36**	.32**	.48**	.27**	.46**	.34**	.48**	.39**	--

Note. Intercorrelations for male and female participants are presented above and below the diagonal, respectively. For T1 correlations, $n = 290$ for boys and $n = 311$ for girls; For T2 correlations, $n = 265$ for boys and $n = 278$ for girls. T1 = Time 1 (Grade 8); T2 = Time 2 (Grade 9); Comp beliefs = math competence beliefs; Ut value = math utility value; Int value = math intrinsic value; Enr intentions = math enrolment Intentions.

* $p < .05$. ** $p < .01$.

Table 3

Model 2: Intercorrelations Between Grades 9 and 10 Variables as a function of Gender

Measure	1	2	3	4	5	6	7	8	9	10
1. Grades (T2)	--	.64**	.76**	.50**	.29**	.30**	.40**	.36**	.35**	.40**
2. Grades (T3)	.55**	--	.48**	.79**	.36**	.48**	.32**	.56**	.33**	.46**
3. Comp beliefs (T2)	.72**	.41**	--	.54**	.46**	.33**	.59**	.41**	.39**	.38**
4. Comp beliefs (T3)	.38**	.74**	.45**	--	.36**	.46**	.38**	.67**	.31**	.41**
5. Ut value (T2)	.28**	.25**	.45**	.23**	--	.66**	.69**	.46**	.49**	.35**
6. Ut value (T3)	.29**	.39**	.38**	.45**	.61**	--	.50**	.65**	.37**	.45**
7. Int value (T2)	.46**	.27**	.65**	.39**	.57**	.50**	--	.61**	.45**	.31**
8. Int value (T3)	.37**	.52**	.43**	.68**	.35**	.61**	.63**	--	.36**	.46**
9. Enr intentions (T2)	.36**	.18**	.46**	.10**	.46**	.29**	.48**	.22**	--	.52**
10. Enr intentions (T3)	.21**	.43**	.27**	.43**	.25**	.46**	.32**	.47**	.39	--

Note. Intercorrelations for male and female participants are presented above and below the diagonal, respectively. For T2 correlations, $\underline{n}$ = 265 for boys and $\underline{n}$ = 278 for girls; For T3 correlations, $\underline{n}$ = 249 for boys and $\underline{n}$ = 255 for girls. T2 = Time 2 (Grade 9); T3 = Time 3 (Grade 10); Comp beliefs = math competence beliefs; Ut value = math utility value; Int value = math intrinsic value; Enr intentions = math enrolment intentions.

* $p < .05$. ** $p < .01$.

Part 2: Model 1 - Grades 8 to 9

The proposed Model 1, examining the longitudinal relations among math-related performance, competence beliefs, task values, and enrolment intentions, was assessed by path analyses. In the hypothesized full path model (shown for boys and girls in Figures 5 and 7, respectively), adolescents' Grade 8 math grades, math competence beliefs and two task values for math served as independent variables. Residual change terms (reflecting changes from Grades 8 to 9) for math competence beliefs, math utility value and math intrinsic value served as intervening variables. Finally, math grades and math enrolment intentions in Grade 9 served as outcome variables. The path analysis was run on residual scores for the intervening variables in order to remove the variance due to Grade 8 variables from the change scores themselves. As such, the residual change score for each intervening variable reflected changes from one measurement point to another, while controlling for the preceding assessment of the variable in question (Cohen & Cohen, 1983).

The proposed model was tested using AMOS 5.0.1 program for the analyses of moment structures (Arbuckle, 2005), and was evaluated separately for girls and boys using the maximum likelihood estimation function of AMOS. According to Schumacker and Lomax (2004), evaluating the significance of a theoretical model (which must have practical meaning in the first place) involves the examination of two major criteria:

(1) First, global fit measures, such as the chi-square value, the Comparative Fit Index (CFI) and the Root-Mean-Square Error of Approximation (RMSEA) need to be evaluated to determine the relative fit of the hypothesized model to the data set in question

(McDonald & Ho, 2002). The chi-square test statistically compares the proposed model with the independence model, whereby the measured variables are assumed to be uncorrelated (Bollen, 1989). The non-statistical significance of the chi-square test indicates that the hypothesized model should be retained over the independence model. The chi-square ratio (χ^2/df) is typically used over the chi-square statistic alone because the latter can be influenced by large sample sizes and model complexity (Byrne, 2001). Along with chi-square ratios between 1 and 3 (Arbuckle & Wothke 1999), CFI values that approximate or exceed .95 (Hu & Bentler, 1999) and RMSEA values less than .05 all reflect a good model fit.

(2) Second, the statistical significance of the individual estimated parameters needs to be examined, along with the magnitude and direction of these estimates. For both Models 1 and 2 in the present study, although all regression paths are evident in the figures, only those that are significant at $p < .01$ or $.001$ are discussed.

For the hypothesized Model 1, three major components were examined: (1) The direction of causality between math competence beliefs and values for math, (2) The relations between adolescents' pre-transition math grades, math competence beliefs and values for math in the prediction of their Grade 9 math performance and math enrolment intentions, and (3) The influence of changes in students' math competence beliefs and values for math from Grades 8 to 9 on their Grade 9 math performance and math enrolment intentions. In the proposed models, rectangles represent the measured variables and the connecting arrows reflect a predicted relation in the direction of the arrow (arrow head pointing to a dependent variable).

Boys

The following twelve structural regression paths were hypothesized for boys: (a) math grades (Grade 8) to math grades (Grade 9); (b) math grades (Grade 8) to math enrolment intentions (Grade 9); (c) math grades (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9); (d) math competence beliefs (Grade 8) to math grades (Grade 8); (e) math competence beliefs (Grade 8) to math grades (Grade 9); (f) math competence beliefs (Grade 8) to changes in math values (residual change scores, Grades 8 to 9); (g) math values (Grade 8) to math enrolment intentions (Grade 9); (h) math values (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9); (i) changes in math competence beliefs (residual change score, Grades 8 to 9) to math grades (Grade 9); (j) changes in math competence beliefs (residual change score, Grades 8 to 9) to changes in math values (residual change scores, Grades 8 to 9); (k) changes in math values (residual change scores, Grades 8 to 9) to math enrolment intentions (Grade 9); (l) changes in math utility value (residual change score, Grades 8 to 9) to changes in math intrinsic value (residual change score, Grades 8 to 9) (path not reflected in model due to the conceptual denotation of utility and intrinsic values for math as a single variable).

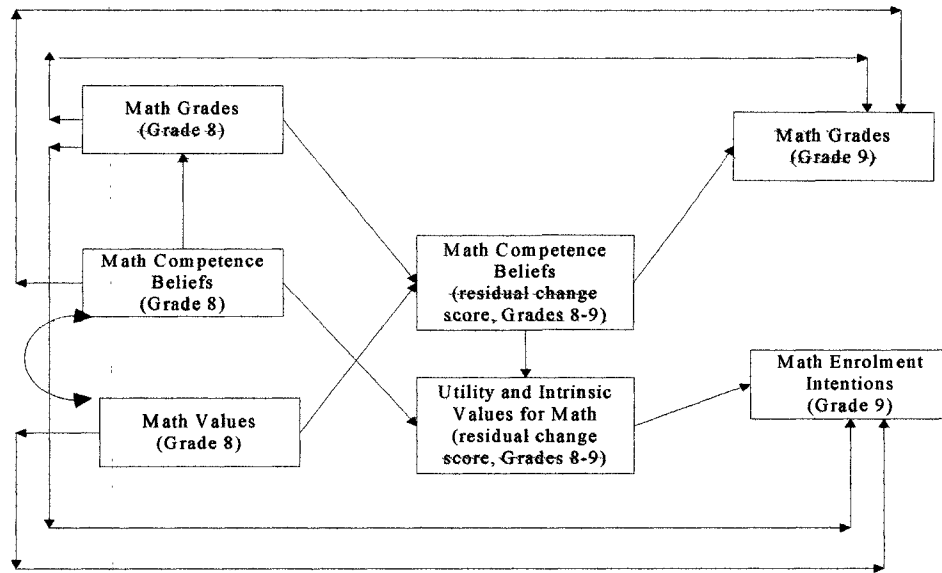


Figure 5. Model 1 for boys (Grades 8 to 9): Hypothesized model of math grades and enrolment intentions.

An examination of the longitudinal path analysis of Model 1 for boys resulted in the rejection of the independence model testing the null hypothesis. The initially specified model fit the data well in terms of all criteria ($\chi^2/df = 1.95$, RMSEA = .05, CFI = .98). When the Likelihood Ratio test of model parameters was examined, the three following insignificant paths were removed (see Table 4): (1) The direct path from math utility value (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9), $\Delta \chi^2(1) = 0.2$, ns., (2) the direct path from math intrinsic value (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9), $\Delta \chi^2(1) = 2.3$, ns., and (3) the direct path from math competence beliefs (Grade 8) to changes in math intrinsic value (residual change score, Grades 8 to 9), $\Delta \chi^2(1) = 1.4$, ns. With these three non-significant paths removed, the model maintained its good fit on all fit indices fit ($\chi^2/df = 1.85$,

RMSEA =.05, CFI =.98) and was retained as the final model. The final Model 1 for boys is presented in Figure 6.

Table 4

Summary of Structural Model Tests on Model 1 for Boys (Grades 8 to 9)

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	CFI	RMSEA
Boys (n = 290)				
Initial Model	31.2 (16)		.985	.057
Remove UV 8 → Res CB	31.4 (17)	0.2 (1)	.985	.054
Remove IV 8 → Res CB	33.7 (18)	2.3 (1)	.984	.055
Remove Res IV → Intentions	35.2 (19)	1.8 (1)	.984	.054

Note. CFI: comparative fit index; RMSEA: root mean square error of approximation; UV 8: utility value for math, Grade 8; IV 8: intrinsic value for math, Grade 8; CB 8: math competence beliefs, Grade 8; Res CB: residual change score for math competence beliefs, Grades 8-9; Res IV: residual change score for intrinsic value for math, Grades 8-9; Intentions: math enrolment intentions, Grade 9.

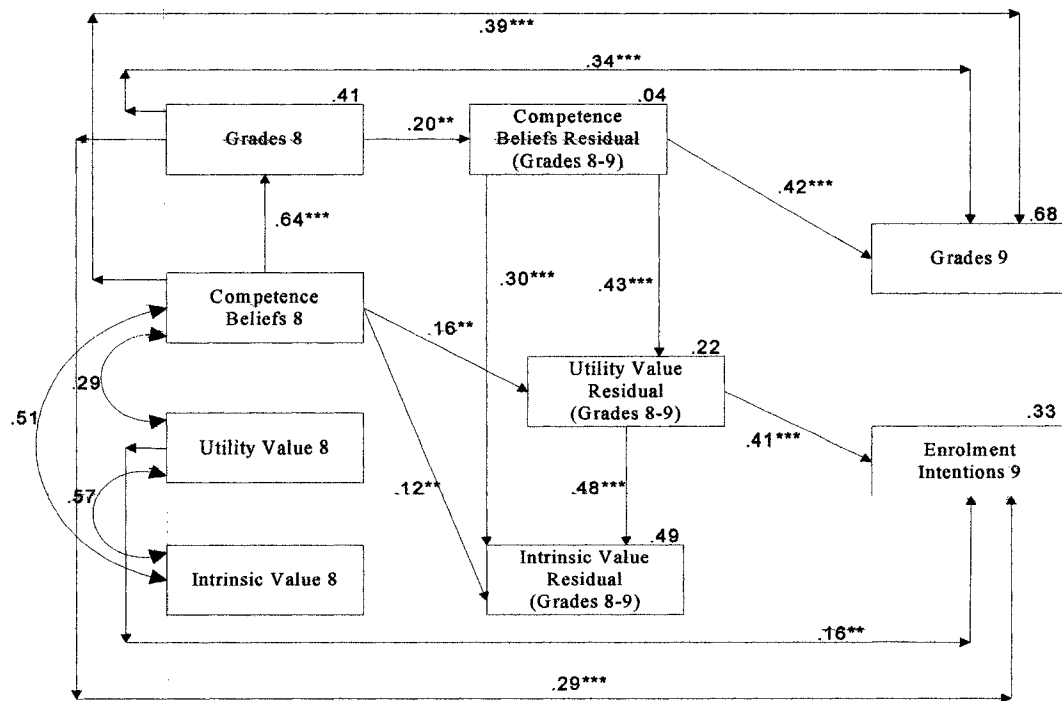


Figure 6. Model 1 for boys (Grades 8 to 9): Final model of math grades and enrolment intentions with maximum likelihood estimates (standardized solution estimates).

** $p < .01$. *** $p < .001$.

The final model for adolescent boys accounted for 68% of the variance in math performance (Grade 9 math grades) and 33% of the variance in math enrolment intentions (Grade 9). In terms of the change variables from Grades 8 to 9, the model explained 4% of the variance of changes in math competence beliefs, 22% of the variance of changes in utility value for math, and 49% of the variance of changes in intrinsic value for math. With respect to the significance and magnitude of each of the specified paths, Table 5 represents the direct path coefficients (unstandardized and standardized), and Table 6 represents the indirect path coefficients (unstandardized and standardized) from this analysis.

Table 5

Model 1 for Boys (Grades 8 to 9): Direct Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	<i>SE</i>	β
From Math Grades (Grade 8) to			
Grades (Grade 9)	0.40	.053	.34***
Enrolment intentions (Grade 9)	0.05	.007	.29***
Comp beliefs (residual change score)	0.01	.005	.20**
From Comp Beliefs (Grade 8) to			
Grades (Grade 8)	7.33	.513	.64***
Grades (Grade 9)	5.12	.603	.39***
Utility value (residual change score)	0.15	.054	.16**
Intrinsic value (residual change score)	0.14	.052	.12**
From Utility Value (Grade 8) to			
Enrolment intentions (Grade 9)	0.24	.076	.16**
From Comp Beliefs (residual change score) to			
Grades (Grade 9)	6.59	.559	.42***
Utility value (residual change score)	0.51	.064	.43***
Intrinsic value (residual change score)	0.42	.068	.30***
From Utility Value (residual change score) to			
Enrolment intentions (Grade 9)	0.62	.078	.41***
Intrinsic value (residual change score)	0.56	.058	.48***

** $p < .01$. *** $p < .001$.

Table 6

Model 1 for Boys (Grades 8 to 9): Indirect Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	β
From Math Grades (Grade 8) to		
Grades (Grade 9)	0.10	.08
Enrolment intentions (Grade 9)	0.02	.03
Utility value (residual change score)	0.02	.09
Intrinsic value (residual change score)	0.01	.10
From Comp Beliefs (Grade 8) to		
Grades (Grade 9)	3.63	.27
Enrolment intentions (Grade 9)	0.41	.27
Comp beliefs (residual change score)	0.11	.13
Utility value (residual change score)	0.05	.05
Intrinsic value (residual change score)	0.16	.14
From Comp Beliefs (residual change score) to		
Enrolment intentions (Grade 9)	0.31	.18
Intrinsic value (residual change score)	0.28	.21

Direct Effects

From Grade 8 math grades. For adolescent boys in our sample, math grades in Grade 8 directly predicted math grades (.34, $p < .001$) and math enrolment intentions (.29, $p < .001$) in Grade 9. Boys' Grade 8 math grades also directly predicted changes in their math competence beliefs from Grades 8 to 9 (.20, $p < .01$). These results support our hypotheses.

From Grade 8 math competence beliefs. As hypothesized, boys' Grade 8 math competence beliefs directly predicted their Grade 8 and Grade 9 math grades (.64 and .39, $p < .001$, respectively). Consistent with a direction of causality from competence beliefs to values, boys' math competence beliefs in Grade 8 predicted changes in their math utility value from Grades 8 to 9 (.16, $p < .01$) and changes in their intrinsic values for math (.12, $p < .01$).

From Grade 8 values for math. Boys' utility value for math in Grade 8 predicted directly their Grade 9 math enrolment intentions (.16, $p < .01$). Contrary to what was hypothesized, boys' intrinsic value for math in Grade 8 was not a significant predictor of their Grade 9 math enrolment intentions. Consistent with our main hypotheses regarding a direction of causality from math competence beliefs to values for math, no significant paths were found between boys' values for math in Grade 8 and changes in their math competence beliefs from Grades 8 to 9.

From changes in math competence beliefs. As predicted, changes in boys' math competence beliefs from Grades 8 to 9 directly predicted their Grade 9 math grades (.42, $p < .001$). With respect to a direction of causality and as predicted, changes in boys' math competence beliefs from Grades 8 to 9 predicted directly changes in their utility value for math (.43, $p < .001$) and changes in their intrinsic valuing of math (.30, $p < .001$) over this same time period.

From changes in values for math. Consistent with our hypotheses, changes in boys' utility value for math from Grades 8 to 9 directly predicted their Grade 9 math enrolment intentions (.41, $p < .001$). However, no significant path was found from changes in their intrinsic value for math from Grades 8 to 9 to their Grade 9 math enrolment intentions. Finally, as we predicted, changes in boys' utility value for math from Grades 8 to 9 predicted directly changes in their intrinsic value for math across this same time period (.48, $p < .001$).

Indirect Effects

Consistent with our hypotheses and with a direction of causality from competence beliefs to values, boys' math competence beliefs in Grade 8 had an indirect effect on their

Grade 9 math enrolment intentions via changes in their utility value for math from Grades 8 to 9 (.09). No support was found for the converse (our alternate hypothesis).

As we had predicted, in addition to a direct effect, boys' Grade 8 math grades had an indirect effect (.08) on their Grade 9 math grades through changes in their math competence beliefs from Grades 8 to 9. In terms of other indirect effects, boys' math competence beliefs in Grade 8 had indirect effects on their Grade 9 math grades (.27) and math enrolment intentions (.27). Changes in boy's math competence beliefs from Grades 8 to 9 indirectly predicted changes in the intrinsic value for math (.21) and their Grade 9 math enrolment (.18), through changes in their utility value for math.

Girls

The following thirteen structural regression paths were hypothesized for girls: (a) math grades (Grade 8) to math grades (Grade 9); (b) math grades (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9); (c) math competence beliefs (Grade 8) to math grades (Grade 8); (d) math competence beliefs (Grade 8) to math grades (Grade 9); (e) math competence beliefs (Grade 8) to math enrolment (Grade 9); (f) math competence beliefs (Grade 8) to changes in math values (residual change scores, Grades 8 to 9); (g) math values (Grade 8) to math enrolment intentions (Grade 9); (h) math values (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9); (i) changes in math competence beliefs (residual change score, Grades 8 to 9) to math grades (Grade 9); (j) changes in math competence beliefs (residual change score, Grades 8 to 9) to math enrolment intentions (Grade 9); (k) changes in math competence beliefs (residual change score, Grades 8 to 9) to changes in math values (residual change scores, Grade 8 to 9); (l)) changes in math values (residual change scores, Grades 8 to 9) to math

enrolment intentions (Grade 9); (m) changes in math utility value (residual change score, Grades 8 to 9) to changes in math intrinsic value (residual change score, Grades 8 to 9) (path not reflected in model due to the conceptual denotation of utility and intrinsic values for math as a single variable).

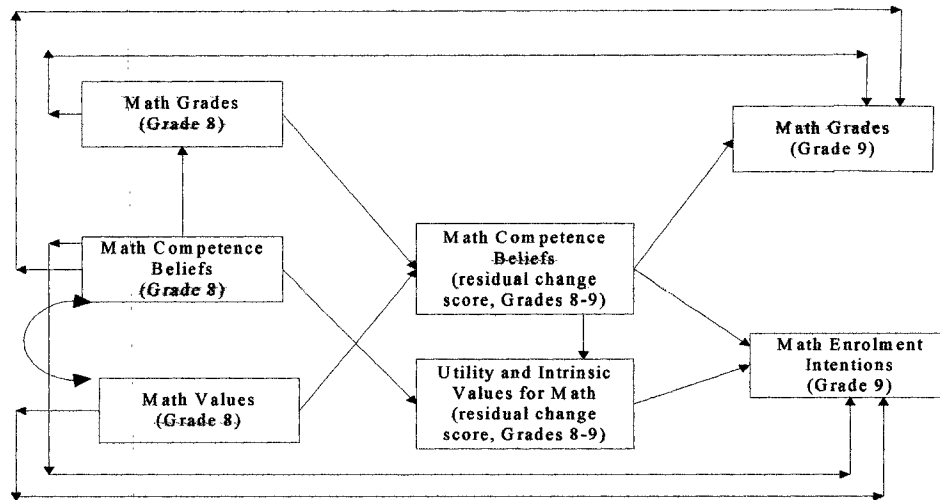


Figure 7. Model 1 for girls (Grades 8 to 9): Hypothesized model of math grades and enrolment intentions.

An examination of the longitudinal path analysis of Model 1 for girls resulted in the rejection of the independence model testing the null hypothesis. The initially specified model fit the data well in terms of all criteria ($\chi^2/df = 2.00$, RMSEA = .05, CFI = .98).

When the Likelihood Ratio test of model parameters was examined, the five following insignificant paths were removed (see Table 7): (1) The direct path from math utility value (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9), $\Delta \chi^2(1) = 1.4$, ns., (2) the direct path from math intrinsic value (Grade 8) to changes in math competence beliefs (residual change score, Grades 8 to 9), $\Delta \chi^2(1) = 1.6$, ns., (3) the direct

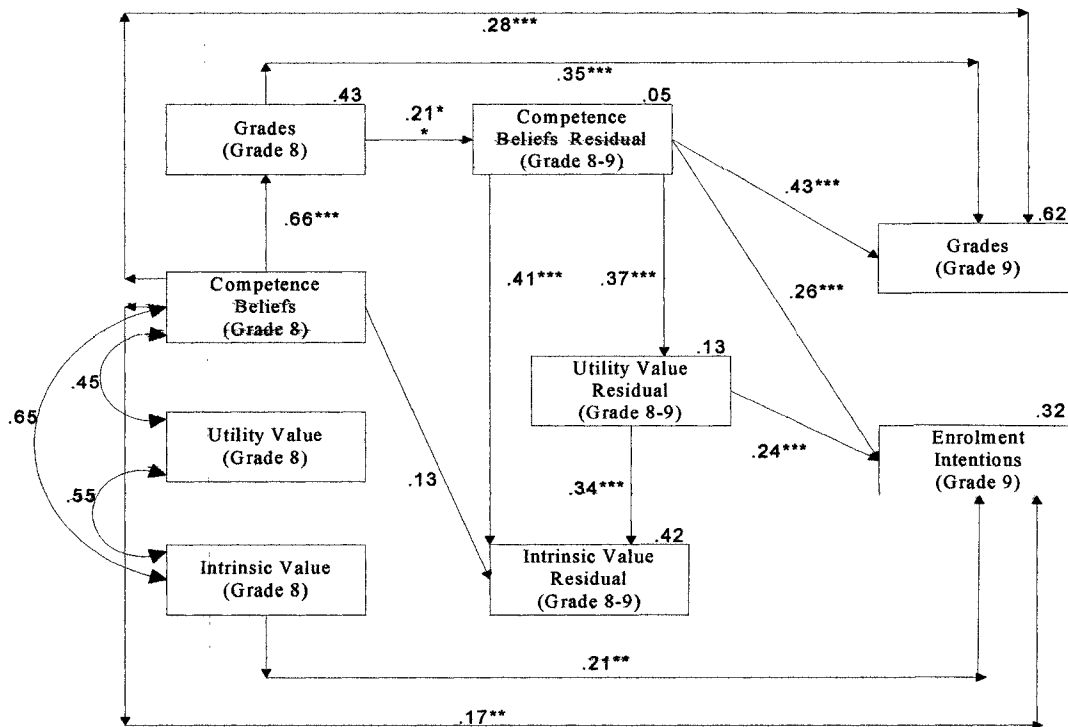
path from math competence beliefs (Grade 8) to changes in math utility value (residual change score, Grades 8 to 9), $\Delta \chi^2 (1) = 2.1$, ns., (4) the direct path from math utility value (Grade 8) to math enrolment intentions (Grade 9), $\Delta \chi^2 (1) = 2.8$, ns., and (5) the direct path from changes in math intrinsic value (residual change score, Grades 8 to 9) to math enrolment intentions (Grade 9), $\Delta \chi^2 (1) = 2.1$, ns. With these five non-significant paths removed, the model maintained its good fit on all fit indices ($\chi^2/df = 2.00$, RMSEA = .05, CFI = .98) and was retained as the final model. The final Model 1 for girls is presented in Figure 8. As mentioned earlier, only paths significant at $p < .01$ or .001 are discussed.

Table 7

Summary of Structural Model Tests on Model 1 for Girls (Grades 8 to 9)

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	CFI	RMSEA
Girls (n = 311)				
Initial Model	30.0 (15)		.985	.057
Remove UV 8 $\rightarrow$ Res CB	31.4 (16)	1.4 (1)	.985	.056
Remove IV 8 $\rightarrow$ Res CB	33.0 (17)	1.6 (1)	.984	.055
Remove CB 8 $\rightarrow$ Res UV	35.1 (18)	2.1 (1)	.983	.055
Remove UV 8 $\rightarrow$ Intentions	37.9 (19)	2.8 (1)	.981	.057
Remove Res IV $\rightarrow$ Intentions	40.0 (20)	2.1 (1)	.980	.057

Note. CFI: comparative fit index; RMSEA: root mean square error of approximation; UV 8: utility value for math, Grade 8; IV 8: intrinsic value for math, Grade 8; CB 8: math competence beliefs, Grade 8; Res CB: residual change score for math competence beliefs, Grades 8-9; Res UV: residual change score for utility value for math, Grades 8-9; Res IV: residual change score for intrinsic value for math, Grades 8-9; Intentions: math enrolment intentions, Grade 9.



^{**} $p < .01$. ^{***} $p < .001$.

The final model for adolescent girls accounted for 62% of the variance in math performance (grades Grade 9) and 32% of the variance in math enrolment intentions (Grade 9). In terms of the prediction of the change variables from Grades 8 to 9, the model explained 5% of the variance of changes in math competence beliefs, 13% of the variance of changes in math utility value, and 42% of the variance of changes in math intrinsic value. With respect to the significance and magnitude of each of the specified paths, Table 8 represents the direct path coefficients (unstandardized and standardized), and Table 9 represents the indirect path coefficients (unstandardized and standardized) from this analysis.

Table 8

Model 1 for Girls (Grades 8 to 9): Direct Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	<i>SE</i>	β
From Grades (Grade 8) to			
Comp beliefs (residual change score)	0.03	.005	.21 ^{***}
Grades (Grade 9)	0.41	.059	.35 ^{***}
From Comp Beliefs (Grade 8) to			
Grades (Grade 8)	6.05	.392	.66 ^{***}
Grades (Grade 9)	2.99	.530	.28 ^{***}
Intrinsic value (residual change score)	0.14	.047	.13
Enrolment intentions (Grade 9)	0.20	.076	.17 ^{**}
From Intrinsic Value (Grade 8) to			
Enrolment intentions (Grade 9)	0.20	.061	.21 ^{**}
From Comp Beliefs (residual change score) to			
Intrinsic value (residual change score)	0.54	.066	.41 ^{***}
Utility value (residual change score)	0.40	.061	.37 ^{***}
Grades (Grade 9)	6.12	.539	.43 ^{***}
Enrolment intentions (Grade 9)	0.40	.082	.26 ^{***}
From Utility Value (residual change score) to			
Intrinsic value (residual change score)	0.42	.060	.34 ^{***}
Enrolment intentions (Grade 9)	0.33	.075	.24 ^{***}

^{**} $p < .01$. ^{***} $p < .001$.

Table 9

Model 1 for Girls (Grades 8 to 9): Indirect Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	β
From Grades (Grade 8) to		
Utility value (residual change score)	0.01	.08
Intrinsic value (residual change score)	0.01	.11
Grades (Grade 9)	0.11	.09
Enrolment intentions (Grade 9)	0.01	.08
From Comp Beliefs (Grade 8) to		
Comp beliefs (residual change score)	0.11	.14
Utility value (residual change score)	0.04	.05
Intrinsic value (residual change score)	0.08	.18
Grades (Grade 9)	3.12	.29
Enrolment intentions (Grade 9)	0.06	.05
From Comp Beliefs (residual change score) to		
Intrinsic value (residual change score)	0.17	.13
Enrolment intentions (Grade 9)	0.31	.09

Direct Effects

From Grade 8 math grades. For adolescent girls in our sample, math grades in Grade 8 directly predicted math grades in Grade 9 (.35, $p < .001$). They also directly predicted changes in girls' math competence beliefs from Grades 8 to 9 (.21, $p < .01$). These results support our hypotheses.

From Grade 8 math competence beliefs. As hypothesized, girls' Grade 8 math competence beliefs directly predicted both their Grades 8 and 9 math grades (.66 and .28, $p < .001$, respectively), as well as their Grade 9 math enrolment intentions (.17, $p < .01$). There was no support of significance at $p < .01$ for our hypothesized direction of causality

from girls' math competence beliefs in Grade 8 to changes in their values for math from Grades 8 to 9.

From Grade 8 values for math. Girls' intrinsic value for math in Grade 8 predicted directly their Grade 9 math enrolment intentions (.17, $p < .01$). Contrary to what was hypothesized, girls' utility value for math in Grade 8 was not a significant predictor of their Grade 9 math enrolment intentions. With respect to the direction of causality from beliefs to values, our alternate hypotheses that values for math might predict math competence beliefs was not supported. Specifically, no significant paths were found between girls' values for math in Grade 8 and changes in their math competence beliefs from Grades 8 to 9.

From changes in math competence beliefs. As predicted, changes in girls' math competence beliefs from Grades 8 to 9 directly predicted their Grade 9 math grades (.43, $p < .001$) and Grade 9 math enrolment intentions (.26, $p < .001$). With respect to a direction of causality and as predicted, changes in girls' math competence beliefs in math from Grades 8 to 9 predicted directly changes in their utility value for math (.37, $p < .001$) and changes in their intrinsic valuing of math (.41, $p < .001$) over this same time period.

From changes in values for math. Consistent with our hypotheses, changes in girls' utility value for math from Grades 8 to 9 directly predicted their Grade 9 math enrolment intentions (.24, $p < .001$). However, no significant path was found from changes in their intrinsic value for math from Grades 8 to 9 to their Grade 9 math enrolment intentions. Finally, as we predicted, changes in girls' utility value for math from Grades 8 to 9 predicted directly changes in their intrinsic value for math across this same time period (.34, $p < .001$).

Indirect Effects

As we had predicted, in addition to a direct effect, girls' Grade 8 math grades had an indirect effect (.09) on their Grade 9 math grades via changes in their math competence beliefs from Grades 8 to 9. In addition, girls' math competence beliefs in Grade 8 had an indirect effect on their math grades in Grade 9 (.29).

Hypothesized Gender Differences

Hypothesis (1). It was hypothesized that the inclusion of the path from Grade 8 math grades to Grade 9 math enrolment intentions for boys, but not for girls, would result in models that would fit the data well for boys and girls. This hypothesis was supported in Model 1.

Hypothesis (2). It was hypothesized that the inclusion of the paths from Grade 8 math competence beliefs to Grade 9 math enrolment intentions and from changes in math competence beliefs from Grades 8 to 9 to Grade 9 math enrolment intentions for girls, but not for boys, would result in models that would fit the data well for boys and girls. This hypothesis was supported in Model 1.

Part 3: Model 2 - Grades 8 to 10

The purpose of Part 3 was to examine the longer-term effects of the transition to high school on adolescents' math-related competence beliefs, values, performance, and enrolment intentions. For the hypothesized Model 2, three major components were examined: (1) The direction of causality between math competence beliefs and values for math, (2) The relations between adolescents' pre-transition math grades, math competence beliefs and values for math in the prediction of their Grade 10 math performance and math enrolment intentions, and (3) The influence of changes in students' math competence

beliefs and values for math from Grades 9 to 10 on their Grade 10 math performance and math enrolment intentions. The hypothesized Model 2, shown separately for boys and girls in Figures 9 and 11, respectively, includes residual change score variables reflecting changes in adolescents' math competence beliefs and two task values for math from Grades 9 to 10.

See Part 1 for a summary of the fit indices used to evaluate Model 2. Consistent with Model 1, in Model 2 rectangles represent the measured variables and the connecting arrows reflect a predicted relation in the direction of the arrow (arrow head pointing to a dependent variable).

Boys

In summary, the following fourteen structural regression paths were hypothesized for boys: (a) math grades (Grade 8) to math grades (Grade 10); (b) math grades (Grade 8) to math enrolment intentions (Grade 10); (c) math grades (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (d) math competence beliefs (Grade 8) to math grades (Grade 8); (e) math competence beliefs (Grade 8) to math grades (Grade 10); (f) math competence beliefs (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (g) math competence beliefs (Grade 8) to changes in math values (residual change scores, Grades 9 to 10); (h) math values (Grade 8) to math enrolment intentions (Grade 10); (i) math values (Grade 8) to changes in math values (residual change scores, Grades 9 to 10); (Grade 8) (j) math values (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (k) changes in math competence beliefs (residual change score, Grades 9 to 10) to math grades (Grade 10); (l) changes in math competence beliefs (residual change score, Grades 9 to 10) to changes in

math values (residual change scores, Grades 9 to 10); (m) changes in math values (residual change scores, Grades 9 to 10) to math enrolment intentions (Grade 10); (n) changes in math utility value (residual change score, Grades 9 to 10) to changes in math intrinsic value (residual change score, Grades 9 to 10) (path not reflected in model due to the conceptual denotation of utility and intrinsic values for math as a single variable).

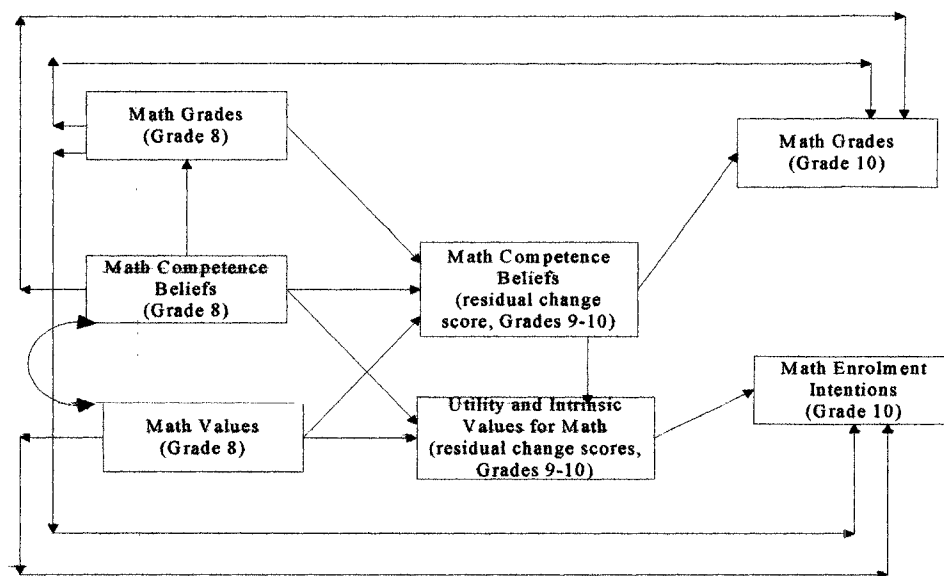


Figure 9. Model 2 for boys (Grades 8 to 10): Hypothesized model of math grades and enrolment intentions.

An examination of the longitudinal path analysis of Model 2 for boys resulted in the rejection of the independence model testing the null hypothesis. The initially specified model fit the data well in terms of the chi square index ($\chi^2/df = 2.95$) and the CFI value (.98). The resulting RMSEA (.08) value was slightly higher than expected, however, improved significantly to RMSEA = .05 when certain insignificant paths were removed.

Specifically, when the Likelihood Ratio test of model parameters was examined, the nine following insignificant paths were removed (see Table 10): (1) The direct path from competence beliefs (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.0$, ns., (2) the direct path from math intrinsic value (Grade 8) to math enrolment intentions (Grade 10), $\Delta \chi^2(1) = 0.0$, ns., (3) the direct path from math utility value (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.1$, ns., (4) the direct path from math utility value (Grade 8) to changes in math utility value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.1$, ns., (5) the direct path from math competence beliefs (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.2$, ns., (6) the direct path from math intrinsic value (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.1$, ns., (7) the direct path from math utility value (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 2.1$, ns., (8) the direct path from math intrinsic value (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 1.4$, ns., (9) the direct path from math competence beliefs (Grade 8) to changes in math utility value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 1.0$, ns. With these nine non-significant paths removed, the model improved its fit on all fit indices ($\chi^2/df = 1.87$, RMSEA = .05, CFI = .98) and was retained as the final model. The final Model 2 for boys is presented in Figure 10.

Table 10
 Summary of Structural Model Tests on Model 2 for Boys (Grades 8 to 10)

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	CFI	RMSEA
Boys (n = 290)				
Initial Model	32.5 (11)		.976	.082
Remove CB 8 → Res IV	32.5 (12)	0.0 (1)	.977	.077
Remove IV 8 → Intentions 10	32.5 (13)	0.0 (1)	.978	.072
Remove UV 8 → Res CB	32.6 (14)	0.1 (1)	.979	.068
Remove UV 8 → Res UV	32.7 (15)	0.1 (1)	.980	.064
Remove CB 8 → Res CB	32.9 (16)	0.2 (1)	.981	.061
Remove IV 8 → Res CB	33.0 (17)	0.1 (1)	.982	.057
Remove UV 8 → Res IV	35.1 (18)	2.1 (1)	.981	.057
Remove IV 8 → Res IV	36.5 (19)	1.4 (1)	.981	.057
Remove CB 8 → Res UV	37.5 (20)	1.0 (1)	.981	.057

Note. CFI: comparative fit index; RMSEA: root mean square error of approximation; CB 8: math competence beliefs, Grade 8; IV 8: intrinsic value for math, Grade 8; UV 8: utility value for math, Grade 8; Res CB: residual change score for math competence beliefs, Grades 9-10; Res IV: residual change score for intrinsic value for math, Grades 9-10; Res UV: residual change score for utility value for math, Grades 9-10; Intentions 10: math enrolment intentions, Grade 10.

** $p < .01$. *** $p < .001$.

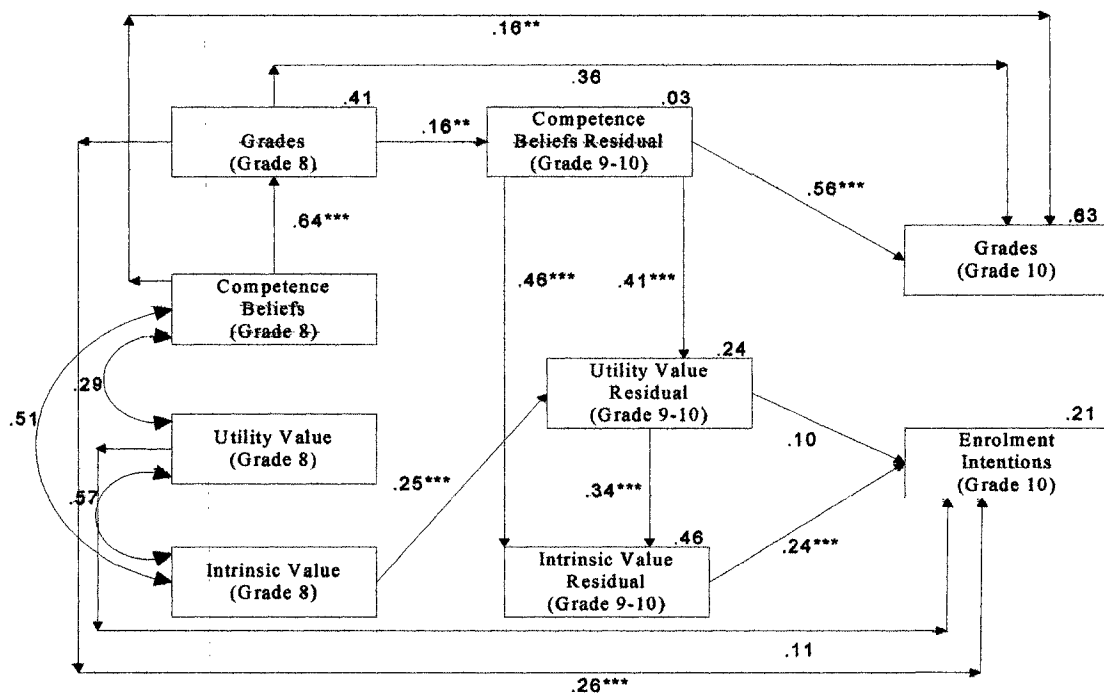


Figure 10. Model 2 for boys (Grades 8 to 10): Final model of math grades and enrolment intentions with maximum likelihood estimates (standardized solution estimates).

** $p < .01$. *** $p < .001$.

The final model for adolescent boys accounted for 63% of the variance in math performance (Grade 10 grades) and 21% of the variance in math enrolment intentions (Grade 10). In terms of the change variables from Grades 9 to 10, the model explained 3% of the variance of changes in math competence beliefs, 24% of the variance of changes in utility value for math, and 46% of the variance of changes in intrinsic value for math. With respect to the significance and magnitude of each of the specified paths, Table 11 represents the direct path coefficients (unstandardized and standardized), and Table 12 represents the indirect path coefficients (unstandardized and standardized) from this analysis.

Table 11

Model 2 for Boys (Grades 8 to 10): Direct Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	<i>SE</i>	β
From Math Grades (Grade 8) to Grades (Grade 10)	0.43	.060	.36***
Enrolment intentions (Grade 10)	0.03	.007	.26***
Comp beliefs (residual change score)	0.02	.006	.16**
From Comp Beliefs (Grade 8) to Grades (Grade 8)	7.33	.513	.64***
Grades (Grade 10)	2.14	.678	.16**
From Utility Value (Grade 8) to Enrolment intentions (Grade 10)	0.16	.083	.11
From Intrinsic Value (Grade 8) to Utility value (residual change score)	0.17	.039	.25***
From Comp Beliefs (residual change score) to Grades (Grade 10)	7.12	.496	.56***
Utility value (residual change score)	0.37	.050	.41***
Intrinsic value (residual change score)	0.52	.056	.46***
From Utility Value (residual change score) to Enrolment intentions (Grade 10)	0.19	.103	.10
Intrinsic value (residual change score)	0.42	.063	.34***
From Intrinsic Value (residual change score) to Enrolment intentions (Grade 10)	0.29	.084	.24***

** $p < .01$. *** $p < .001$.

Table 12

Model 2 for Boys (Grades 8 to 10): Indirect Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	β
From Math Grades (Grade 8) to		
Grades (Grade 10)	0.11	.09
Enrolment intentions (Grade 10)	0.00	.03
Utility value (residual change score)	0.01	.07
Intrinsic value (residual change score)	0.01	.10
From Comp Beliefs (Grade 8) to		
Grades (Grade 10)	3.92	.29
Enrolment intentions (Grade 10)	0.27	.18
Comp beliefs (residual change score)	0.11	.10
Utility value (residual change score)	0.04	.04
Intrinsic value (residual change score)	0.07	.06
From Intrinsic Value (Grade 8) to		
Enrolment intentions (Grade 10)	0.05	.05
Intrinsic value (residual change score)	0.07	.09
From Comp Beliefs (residual change score) to		
Enrolment intentions (Grade 10)	0.25	.18
Intrinsic value (residual change score)	0.15	.14
From Utility Value (residual change score) to		
Enrolment intentions (Grade 10)	0.12	.08

Direct Effects

From Grade 8 math grades. For adolescent boys in our sample, math grades in Grade 8 predicted directly both their math grades (.36, $p < .001$) and math enrolment intentions (.26, $p < .001$) in Grade 10. Boys' Grade 8 math grades also directly predicted changes in their math competence beliefs from Grades 9 to 10 (.16, $p < .01$). These results support our hypotheses.

From Grade 8 math competence beliefs. As hypothesized, boys' Grade 8 math competence beliefs directly predicted their Grade 8 and Grade 10 math grades (.64 and .16,

$p < .001$, respectively). With respect to direction of causality and contrary to what we predicted, there were no significant direct paths from Grade 8 math competence beliefs to changes in boys' utility and intrinsic values for math from Grades 9 to 10.

From Grade 8 values for math. Contrary to what we predicted, boys' values in Grade 8 did not predict directly their math enrolment intentions in Grade 10. Also, no significant direct paths were found from boys' utility or intrinsic values for math in Grade 8 to changes in their math competence beliefs from Grades 9 to 10. As such, no support was found for our secondary hypothesis regarding the direction of causality from values to competence beliefs. From boys' Grade 8 values for math, the only significant path in our model was from intrinsic value in Grade 8 to changes in their utility value from Grades 9 to 10 (.25, $p < .001$).

From changes in math competence beliefs. As predicted, changes in boys' math competence beliefs from Grades 9 to 10 directly predicted their Grade 10 math grades (.56, $p < .001$). With respect to direction of causality and as predicted, changes in boys' math competence beliefs from Grades 9 to 10 predicted directly changes in their utility value for math (.41, $p < .001$) and changes in their intrinsic valuing of math (.46, $p < .001$) over this same time period.

From changes in values for math. Results concerning paths from changes in boys' values for math only partially supported our hypotheses. Specifically, changes in boys' intrinsic value for math from Grades 9 to 10 directly predicted their Grade 10 math enrolment intentions (.24, $p < .001$), whereas changes in their utility value for math across this same period did not. As such, no support was found for our hypothesis that changes in utility value for math from Grades 9 to 10 would be a stronger predictor of students' Grade

10 math enrolment intentions than would be changes in math intrinsic value. Finally, consistent with our hypothesis, changes in boys' utility value for math from Grades 9 to 10 predicted directly changes in their intrinsic value for math across this same time period (.34, $p < .001$).

Indirect Effects

In Model 2 we found no significant paths from boys' Grade 8 math competence beliefs to changes in their values for math from Grades 9 to 10 and no significant paths from boys' Grade 8 values for math to changes in their math competence beliefs from Grades 9 to 10. As such, there was no indirect effect of boys' Grade 8 math competence beliefs on their Grade 10 math enrolment intentions via changes in their values for math from Grades 9 to 10. Similarly, there was no indirect effect of boys' Grade 8 values for math on their Grade 10 math grades via changes in their math competence beliefs from Grades 9 to 10. Given these results, in Model 2 we were unable to address our hypotheses regarding the direction of causality between math competence beliefs and values for math.

As we had predicted, in addition to a direct effect, boys' Grade 8 math grades had an indirect effect (.09) on their Grade 10 math grades through changes in their math competence beliefs from Grades 9 to 10. In terms of other indirect effects, boys' math competence beliefs in Grade 8 had indirect effects on their Grade 10 math grades (.29) and math enrolment intentions (.18). Changes in boys' math competence beliefs from Grades 9 to 10 indirectly predicted changes in their intrinsic value for math (.14), through changes in their utility value for math. They also indirectly predicted their Grade 10 math enrolment (.18), through changes in values for math.

Girls

In summary, the following fifteen structural regression paths were hypothesized for girls: (a) math grades (Grade 8) to math grades (Grade 10); (b) math grades (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (c) math competence beliefs (Grade 8) to math grades (Grade 8); (d) math competence beliefs (Grade 8) to math grades (Grade 10); (e) math competence beliefs (Grade 8) to math enrolment intentions (Grade 10); (f) math competence beliefs (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (g) math competence beliefs (Grade 8) to changes in math values (residual change scores, Grades 9 to 10); (h) math values (Grade 8) to math enrolment intentions (Grade 10); (i) math values (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10); (j) math values (Grade 8) to changes in math values (residual change scores, Grades 9 to 10); (k) changes in math competence beliefs (residual change score, Grades 9 to 10) to math grades (Grade 10); (l) changes in math competence beliefs (residual change score, Grades 9 to 10) to math enrolment intentions (Grade 10); (m) changes in math competence beliefs (residual change score, Grades 9 to 10) to changes in math values (residual change scores, Grade 9 to 10); (n) changes in math values (residual change scores, Grades 9 to 10) to math enrolment intentions (Grade 10); (o) changes in math utility value (residual change score, Grades 9 to 10) to changes in math intrinsic value (residual change score, Grades 9 to 10) (path not reflected in model due to the conceptual denotation of utility and intrinsic values for math as a single variable).

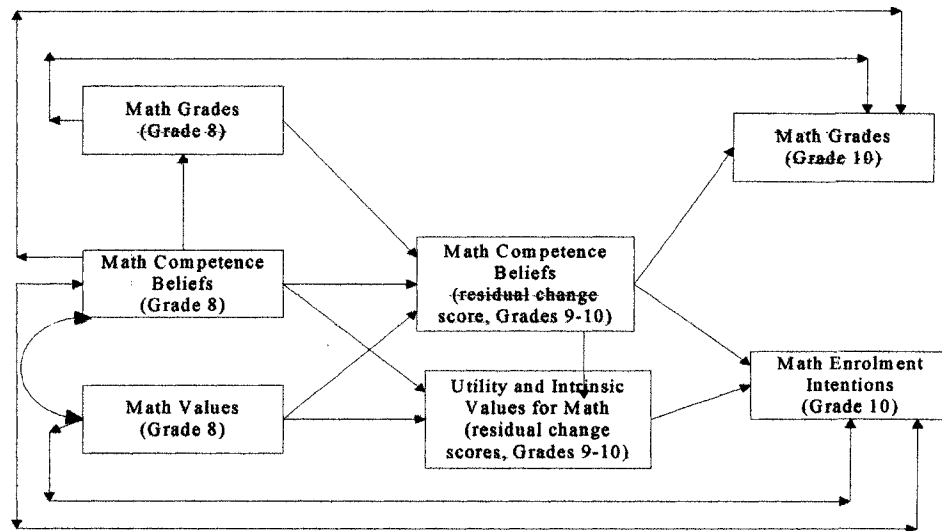


Figure 11. Model 2 for girls (Grades 8 to 10): Hypothesized model of math grades and enrolment intentions.

An examination of the longitudinal path analysis of Model 2 for girls resulted in the rejection of the independence model testing the null hypothesis. The initially specified model fit the data adequately well ($\chi^2/df = 2.72$, RMSEA = .07, CFI = .98). When the Likelihood Ratio test of model parameters was examined, the eight following insignificant paths were removed (see Table 13): (1) The direct path from math competence beliefs (Grade 8) to changes in math competence beliefs (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.1$, ns., (2) the direct path from math competence beliefs (Grade 8) to changes in math utility value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.3$, ns., (3) the direct path from math intrinsic value (Grade 8) to changes in math utility value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.2$, ns., (4) the direct path from math utility value (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2(1) = 0.6$, ns., (5) the direct path from math competence beliefs (Grade 8) to math enrolment

intentions (Grade 10) $\Delta \chi^2 (1) = 0.9$, ns., (6) the direct path from math competence beliefs (Grade 8) to math grades (Grade 10), $\Delta \chi^2 (1) = 0.9$, ns., (7) the direct path from math competence beliefs (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2 (1) = 1.0$, ns., and (8) the direct path from math intrinsic value (Grade 8) to changes in math intrinsic value (residual change score, Grades 9 to 10), $\Delta \chi^2 (1) = 0.4$, ns., With these eight non-significant paths removed, the model improved its fit on all fit indices ($\chi^2/df = 1.75$, RMSEA = .05, CFI = .99) and was retained as the final model. The final Model 2 for girls is presented in Figure 12. As mentioned earlier, only paths significant at $p < .01$ or .001 are discussed.

Table 13

Summary of Structural Model Tests on Model 2 for Girls (Grades 8 to 10)

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	CFI	RMSEA
Girls (n = 311)				
Initial Model	27.2 (10)		.982	.075
Remove CB 8 $\rightarrow$ Res CB	27.3 (11)	0.1	.983	.069
Remove CB 8 $\rightarrow$ Res UV	27.6 (12)	0.3 (1)	.984	.065
Remove IV 8 $\rightarrow$ Res UV	27.8 (13)	0.2 (1)	.984	.061
Remove UV 8 $\rightarrow$ Res IV	28.4 (14)	0.6 (1)	.985	.058
Remove CB 8 $\rightarrow$ Intentions 10	29.3 (15)	0.9 (1)	.985	.055
Remove CB 8 $\rightarrow$ Grades 10	30.2 (16)	0.9 (1)	.985	.054
Remove CB 8 $\rightarrow$ Res IV	31.2 (17)	1.0 (1)	.985	.052
Remove IV 8 $\rightarrow$ Res IV	31.6 (18)	0.4 (1)	.985	.049

Note. CFI: comparative fit index; RMSEA: root mean square error of approximation; CB 8: math competence beliefs, Grade 8; IV 8: intrinsic value for math, Grade 8; UV 8: utility value for math, Grade 8; Res CB: residual change score for math competence beliefs, Grades 9-10; Res UV: residual change score for utility value for math, Grades 9-10; Res IV: residual change score for intrinsic value for math, Grades 9-10; Intentions 10: math enrolment intentions, Grade 10; Grades 10: Math grades, Grade 10.

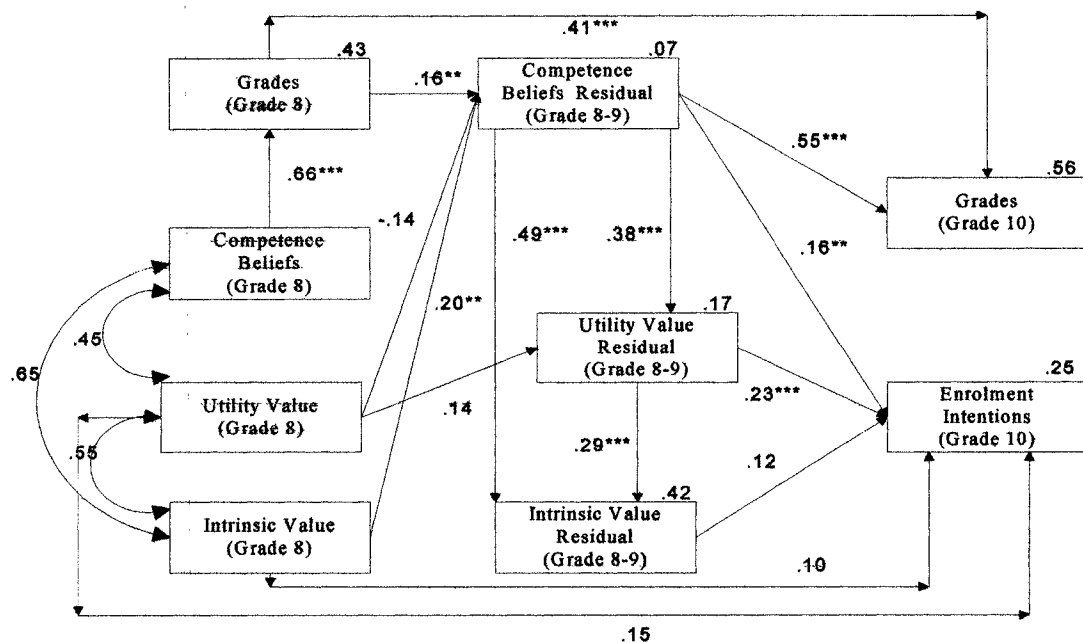


Figure 12. Model 2 for girls (Grades 8 to 10): Final model of math grades and enrolment intentions with maximum likelihood estimates (standardized solution estimates).

** $p < .01$. *** $p < .001$.

The final model for adolescent girls accounted for 56% of the variance in math performance (Grade 10 grades) and 25% of the variance in math enrolment intentions (Grade 10). In terms of the change variables from Grades 9 to 10, the model explained 7% of the variance of changes in math competence beliefs, 17% of the variance of changes in utility value for math, and 42% of the variance of changes in intrinsic value for math. With respect to the significance and magnitude of each of the specified paths, Table 14 represents the direct path coefficients (unstandardized and standardized), and Table 15

represents the indirect path coefficients (unstandardized and standardized) from this analysis.

Table 14

Model 2 for Girls (Grades 8 to 10): Direct Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	<i>SE</i>	<i>β</i>
From Math Grades (Grade 8) to Grades (Grade 10)	0.51	.053	.41 ^{***}
Comp beliefs (residual change score)	0.02	.007	.16 ^{**}
From Comp Beliefs (Grade 8) to Grades (Grade 8)	6.05	.392	.66 ^{***}
From Utility Value (Grade 8) to Enrolment intentions (Grade 10)	0.17	.077	.15
Comp beliefs (residual change score)	- 0.14	.076	- .14
Utility value (residual change score)	0.13	.053	.14
From Intrinsic Value (Grade 8) to Enrolment intentions (Grade 10)	0.08	.058	.10
Comp beliefs (residual change score)	0.15	.060	.20 ^{***}
From Comp Beliefs (residual change score) to Grades (Grade 10)	6.48	.507	.55 ^{***}
Enrolment intentions (Grade 10)	0.18	.078	.16 ^{**}
Utility value (residual change score)	0.34	.051	.38 ^{***}
Intrinsic Value (residual change score)	0.51	.054	.49 ^{***}
From Utility Value (residual change score) to Enrolment intentions (Grade 10)	0.29	.080	.23 ^{***}
Intrinsic value (residual change score)	0.35	.061	.29 ^{***}
From Intrinsic Value (residual change score) to Enrolment intentions (Grade 10)	0.13	.077	.12

^{**} $p < .01$. ^{***} $p < .001$.

Table 15

Model 2 for Girls (Grades 8 to 10): Indirect Path Coefficients (Unstandardized and Standardized)

Path	<i>B</i>	β
From Math Grades (Grade 8) to		
Grades (Grade 10)	0.11	.09
Enrolment intentions (Grade 10)	0.01	.05
Utility value (residual change score)	0.01	.06
Intrinsic value (residual change score)	0.01	.10
From Comp Beliefs (Grade 8) to		
Grades (Grade 10)	3.72	.33
Enrolment intentions (Grade 10)	0.04	.03
Comp beliefs (residual change score)	0.10	.10
Utility value (residual change score)	0.03	.04
Intrinsic value (residual change score)	0.06	.06
From Utility Value (Grade 8) to		
Grades (Grade 10)	- 0.93	- .08
Enrolment intentions (Grade 10)	- 0.07	- .06
Utility value (residual change score)	- 0.05	- .05
Intrinsic value (residual change score)	- 0.05	- .04
From Intrinsic Value (Grade 8) to		
Grades (Grade 10)	1.00	.11
Enrolment intentions (Grade 10)	0.06	.06
Utility value (residual change score)	0.05	.08
Intrinsic value (residual change score)	0.08	.12
From Comp Beliefs (residual change score) to		
Enrolment intentions (Grade 10)	0.18	.16
Intrinsic value (residual change score)	0.12	.11
From Utility Value (residual change score) to		
Enrolment intentions (Grade 10)	0.05	.04

Direct Effects

From Grade 8 math grades. For adolescent girls in our sample, math grades in Grade 8 directly predicted math grades in Grade 10 (.41, $p < .001$). They also directly predicted changes in girls' math competence beliefs from Grades 9 to 10 (.16, $p < .01$). These results support our hypotheses.

From Grade 8 math competence beliefs. Girls' math competence beliefs in Grade 8 directly predicted their Grades 8 math grades (.66, $p < .001$). The remainder of our hypotheses pertaining to this variable were not supported. Specifically, no direct paths were found from girls' Grade 8 math competence beliefs to their Grade 10 math grades and math enrolment intentions, or to changes in their math competence beliefs and values from Grades 9 to 10.

From Grade 8 values for math. Our hypotheses pertaining to girls' Grade 8 values for math were largely not supported. We found no significant direct paths at the $p < .01$ level from Grade 8 math values to girls' Grade 10 math enrolment intentions or to changes in their values for math from Grades 9 to 10. There was a significant path from girls' intrinsic value for math, but not utility value for math, in Grade 8 to changes in their math competence beliefs from Grades 9 to 10 (.20, $p < .001$). As such, with respect to the direction of causality between beliefs and values, our alternate hypotheses that values for math might predict math competence beliefs was only partially supported.

From changes in math competence beliefs. As predicted, changes in girls' math competence beliefs from Grades 9 to 10 directly predicted their Grade 10 math grades (.55, $p < .001$) and Grade 10 math enrolment intentions (.16, $p < .01$). Also as predicted, changes in girls' math competence beliefs in math from Grades 9 to 10 predicted directly changes in

their utility value for math (.38, $p < .001$) and changes in their intrinsic valuing of math (.49, $p < .001$) over this same time period.

From changes in values for math. In partial support of our hypothesis regarding the predictive effect of changes in values on math enrolment intentions, changes in girls' utility value, but not intrinsic value for math, from Grades 9 to 10 directly predicted their Grade 10 math enrolment intentions (.23, $p < .001$). As such, our other hypothesis regarding changes in math utility value from Grades 9 to 10 being a stronger predictor of Grade 10 math enrolment intentions than changes in math intrinsic value of math over this same period was supported for girls in the present study. Finally, consistent with what we hypothesized, changes in girls' utility value for math from Grades 9 to 10 predicted directly changes in their intrinsic value for math across this same time period (.29, $p < .001$).

Indirect Effects

In Model 2, with respect to a direction of causality, we found no significant paths from girls' Grade 8 math competence beliefs to changes in their values for math from Grades 9 to 10. As such, there was no indirect effect of girls' Grade 8 math competence beliefs on their Grade 10 math enrolment intentions via changes in their values for math from Grades 9 to 10. In terms of our alternate hypothesis regarding direction of causality between competence beliefs and values, there was a significant path from girls' Grade 8 intrinsic value for math to changes in their math competence beliefs from Grades 9 to 10. Thus, there was an indirect effect of girls' intrinsic value for math in Grade 8 on their Grade 10 math grades (.11) via changes in their math competence beliefs from Grades 9 to 10. Finally, changes in math competence beliefs from Grades 9 to 10 indirectly predicted changes in girls' intrinsic value for math (.11) via changes in their utility value for math.

As we had predicted, in addition to a direct effect, girls' Grade 8 math grades had an indirect effect (.09) on their Grade 10 math grades via changes in their math competence beliefs from Grades 9 to 10. Changes in girls' math competence beliefs from Grades 9 to 10 indirectly predicted their Grade 10 math enrolment intentions (.16) through changes in their values for math. In terms of other indirect effects, girls' math competence beliefs in Grade 8 predicted indirectly their Grade 10 math grades (.33).

Hypothesized Gender Differences

Hypothesis (1). It was hypothesized that the inclusion of the path from Grade 8 math grades to Grade 10 math enrolment intentions for boys, but not for girls, would result in models that would fit the data well for boys and girls. This hypothesis was supported in Model 2.

Hypothesis (2). It was hypothesized that the inclusion of the paths from Grade 8 math competence beliefs to Grade 10 math enrolment intentions and from changes in math competence beliefs from Grades 9 to 10 to Grade 10 math enrolment intentions for girls, but not for boys, would result in models that would fit the data well for boys and girls, respectfully. This hypothesis was supported in Model 2. However, the insignificant path from girls' Grade 8 math competence beliefs to their Grade 10 math enrolment intentions was removed from Model 2 (see Table 13), with no overall changes in the fit indices. As such, Model 2 fit the data well for girls with the inclusion of the path from changes in math competence beliefs (from Grades 9 to 10) to math enrolment intentions (Grade 10).

DISCUSSION

The purpose of the present study was three-fold:

In Part 1, mean-level changes and the stability of adolescents' math performance, math competence beliefs, values for math, and math enrolment intentions were examined within a longitudinal framework. Specifically, using data collected from the same students in Grades 8, 9, and 10, we examined mean-level changes in these variables and assessed their stability across time: From Grades 8 to 9 as students make the transition to high school and from Grades 9 to 10 in the year immediately following the transition to high school.

In Part 2, we tested a path analytic model (Model 1) which allowed us to examine different components of students' transition to high school (from Grades 8 to 9). First, we assessed the direction of causality between math competence beliefs and values for math by including bi-directional paths in the model between these variables. Second, we examined the predictive role of students' Grade 8 (pre-transition) math performance, math competence beliefs, and task values for math on their Grade 9 math performance and math enrolment intentions. Third, we looked at the influence of changes in students' math competence beliefs and task values for math (residual change scores from Grades 8 to 9) on their math performance and math enrolment intentions in Grade 9, and at their intermediary role between the Grade 8 variables and the Grade 9 outcome variables. In Part 2, we were interested exclusively in the transition to high school period, such that only Grade 8 and Grade 9 variables were included in the model (Model 1).

In Part 3, we tested another longitudinal model (Model 2) that included data from all three years of our study (Grades 8, 9, and 10). First, we assessed the direction of

causality between math competence beliefs and values for math by including bi-directional paths in the model between these variables. Second, we examined the predictive role of students' Grade 8 (pre-transition) math performance, math competence beliefs, and task values for math on their Grade 10 math performance and math enrolment intentions. In Model 2, we were interested in the longer term predictive effects of Grade 8 variables on students' math performance and math enrolment intentions two years into high school. Third, we looked at the influence of changes in students' math competence beliefs and task values for math (residual change scores from Grades 9 to 10) on their math performance and math enrolment intentions in Grade 10, and at their intermediary role between the Grade 8 variables and the Grade 10 outcome variables.

Whenever possible, the results of the present study will be compared with past empirical data and theoretical models. However, to our knowledge, to date there is no research examining the predictive role of changes in students' math competence beliefs and values on their math performance and math enrolment intentions. Although there is ample evidence to support the occurrence of negative changes in these variables across the transition to the high school period, no study has looked at whether and how the changes themselves are predictive of students' future math performance and intentions to enroll in subsequent math courses. As such, the present study provides a unique and first-time examination of the role of change (in math competence beliefs and task values for math) in the prediction of math performance and math enrolment intentions across and after the transition to high school.

Part 1

In the present study, mean-level changes and stability correlations were examined, providing important information about the continuity of math performance, math competence beliefs, values for math, and math enrolment intentions across and after the transition to high school period (across Grades 8, 9, and 10). When combined, the results of these two measures of continuity provide an image of the developmental trajectory of each variable as students move from Grade 8 through to Grade 10.

Examining mean-level changes enabled us to assess group stability across time (Roberts & Delvecchio, 2000), and provided information about how each variable mean changed across Grades 8, 9, and 10. Stability correlations, as a complementary measure of continuity, provided us with information about the predictability of a person's position within a group and about how that person's position, relative to that larger group, changed from Grades 8, 9, and 10. As mentioned earlier, results of stability correlations with r values of .50 or greater reflect moderate to solid stability (Eccles et al., 1989; Wigfield et al., 1997). Gender differences in these changes for each of the variables are discussed.

In Hypotheses 1 through 4, decreases in the mean-levels of math competence beliefs, utility and intrinsic values for math, math performance, and math enrolment intentions were expected across Grades 8, 9, and 10. In terms of stability correlations, with the exception of math enrolment intentions, we predicted that the stability of students' math competence beliefs, utility and intrinsic values for math, and math performance would increase across and after the transition to high school. As such, we expected that the correlation coefficients for these variables from Grades 9 to 10 would be greater than those

from Grades 8 to 9. For math enrolment intentions, we hypothesized a decrease in stability across Grades 8, 9, and 10.

The Continuity of Math Competence Beliefs and Values for Math

Mean-level Changes in Math Competence Beliefs

With respect to mean-level changes in math competence beliefs, boys and girls both showed mean-level declines across time as we had predicted. Also consistent with our hypotheses, boys had higher ratings of math competence beliefs than did girls across Grades 8, 9, and 10 on average.

Our result regarding the gender difference favouring boys in math competence beliefs is a finding that is frequently reported in the literature (e.g., Juang & Silbereisen, 2002). In her recent longitudinal study involving over 300 first through fifth grade children, Herbert (2005) found that girls rated their math competence beliefs lower than did boys, and that this gender difference began as early as in Grade 3. Interestingly, this gender gap was found to be present even when the girls outperformed boys on math achievement measures. Results of other studies also lend support to this finding (e.g., Crombie et al., 2005; Fredricks & Eccles, 2002; Stipek & Gralinski, 1991). For example, Fredricks and Eccles (2002) found gender differences among high school students, favouring boys in math competence beliefs. Using growth models to project developmental trends, they estimated that this gender gap would narrow as children got older.

Predictions about the future of gender differences in math competence beliefs are mixed. Supporters of the gender-intensification theory believe that gender-role socialization will lead to increases in gender differences in math, particularly during early adolescence, when pubertal changes are likely to fuel existing gender-role socialization

practices (e.g., Eccles et al., 1987; Hill & Lynch 1983). On the other side of the debate, some researchers believe that the gender gap in math competence beliefs favouring boys will decrease over time (Ruble & Martin, 1998). Proponents of this position argue that social pressures promoting gender egalitarianism will lead to changes in children's home and school environments, enabling girls to hold equal views to boys of their math competence beliefs (Hyde et al., 1990). Whether or not gender differences in math competence beliefs narrow overtime, it is disconcerting that the girls in the present study continue to rate their math competence lower than do boys, even in the absence of any performance differences. Girls' math competence beliefs have been found to predict both their math performance and their intentions to enroll in future math courses. At a practical level, if we are interested in addressing the under-representation of women in math- and science-related fields, intervention needs to begin in elementary school and continue on through to high school. Efforts to build girls' perceptions of their math ability need to be actively and directly integrated into early educational programs rather than being a later response to an already established problem.

Despite the gender gap favouring boys, our results show that both boys and girls' math competence beliefs declined across Grades 8, 9, and 10. Mean-level decreases in math competence beliefs over time are findings that are also well established in the literature. In a longitudinal study involving children across Grades 1 to 12, Fredricks and his colleagues found that decreases in math competence beliefs begin at an early developmental time period—presenting in middle elementary school and continuing on through the later school years (Wigfield et al., 1997). Eccles (2005) found decreases in

math competence beliefs for both boys and girls across the elementary and high school years.

A variety of explanations have been put forth to shed light on children's and adolescents' decreasing levels of math competence beliefs over time. Researchers who have found decreases in math competence beliefs among early and middle elementary school-aged children believe that one reason for the drop is due to the initially over-optimistic ability perceptions held by children (Fredricks & Eccles, 2002; Nicholls & Miller, 1984; Stipek & MacIver, 1989; Wigfield et al., 1997). Young children's unrealistically high competence beliefs develop in part from an academic environment that promotes the value of effort as a measure of ability and a more cooperative, rather than competitive, learning atmosphere. Young children, compared with older youth, are also less likely to compare their performance to that of other children and are less able to integrate different kinds of evaluative feedback – both of which are important in their understanding of their own performance (Eccles et al., 1984; Nicholls, 1979, 1990).

In research with older children, the timeframe within which students make the transition to high school is an important developmental period in which to examine changes in students' math competence beliefs and values for math (Barber & Olsen, 2004; Seidman et al., 1994; Tam et al., 2000). During this period, decreases in math competence beliefs have been attributed in part to the stress associated with multiple co-occurring changes and to a misfit between the high school academic environment and adolescents social and developmental needs. Changes in the academic learning environment that have been related to some of the difficulties students' experience when making the transition from elementary to high school include: evaluation feedback that is based more on formal

testing than on mastery-based criteria, an emphasis on ability more than the role of effort, and a more competitive academic environment with a related increase in social comparisons (Cantin, 2004; Eccles, Midgley, et al., 1993; Fredrick & Eccles, 2002; Watt, 2004).

Stability of Math Competence Beliefs

Our results regarding the stability of math competence beliefs as a construct were consistent with the findings of other researchers (Eccles et al., 1989; Fredricks & Eccles, 2002). Over the three-year measurement period, the construct of math competence beliefs during adolescence showed moderate stability (r s averaging .58 and .55 for boys and girls, respectively). The construct of competence beliefs is believed to become more stable over the elementary, middle, and high school years because children receive increasingly more feedback about their abilities and are better able with age to distinguish between ability and effort as determinants of their success.

Cross-time stability correlations of an individual's position within a larger group did not support our hypothesis for math competence beliefs. In the present study, we found that girls not only had lower mean levels of math competence than did boys, but their math competence beliefs decreased in stability across and following the transition to high school (Grades 8, 9, and 10). Boys on the other hand, showed no changes in the stability of their math competence beliefs across this same time period.

Changes in the classroom organization, task structure, grouping practices, and evaluation techniques in high school may have a more negative effect on girls than on boys in the subject area of mathematics. Perceived changes in the learning environment toward a more performance-based orientation have been shown to affect girls and boys differently

(Bong, 2005). Although an elaborate discussion of gender differences in learning strategies goes beyond the scope of this paper, studies have found that there is a tendency for girls to hold a more mastery and less performance orientation to learning than do boys (Patrick, Ryan, & Pintrich, 1999; Ryan & Pintrich, 1997). Boys on the other hand tend to adopt a more performance-based orientation to learning than do girls (Ablard & Lipschultz, 1998; Meece & Holt, 1993). Changes in the high school learning environment, specifically the promotion of competitiveness and comparative performance evaluations (Maehr & Midgley, 1996), fewer opportunities for joint-decision making (MacIver & Reuman, 1988), and a more stringent grading criteria leading to decreased grades are all factors that work against a mastery approach to learning. Given that the performance-based orientation in high school is more consistent with the learning approaches of boys, it is conceivable that only girls in our study showed a decrease in the stability of their math competence beliefs across and after the transition period.

There is some suggestion that students' perceptions of their learning environment as mastery versus performance oriented affects their personal approach to school work (Church, Elliot, & Gable, 2001). Accordingly, researchers have found that perceptions of a more performance-based orientation to learning are associated with drops in mastery achievement goals (Anderman & Midgley, 1997). Thus, it would be reasonable to expect that girls would adjust their learning approaches to better fit their perceptions of a performance-based high school academic environment.

The association, however, between perceived learning environment approach and personal orientation to learning appears to vary as a function of the subject area and context in question. For example, Urdan and Midgley (2003) found that when students perceived

their academic environment as performance based, they increased their personal performance goals at the general school level. However, no increases in performance goals were associated with the same performance-based perceptions when it came to their learning approach to math. In another recent study assessing students' motivation and learning environment perceptions, Bong (2005) reported that despite teenage girls' perception of a reduced mastery focus and more performance based learning environment in high school, they neither increased their use of performance-approach goals nor reduced their personal mastery orientation when it came to math.

In light of these findings, it is not surprising that we found a decrease in the stability of girls, but not boys', math competence beliefs across and after the transition to high school. When it comes to boys and girls' math competence beliefs, the differential effects of the transition to high school period may be explained in part by the misfit between girls' learning orientation and their perceptions of a performance-based math class environment in high school, coupled with their existing lower levels of math ability perceptions.

Mean-level Changes in Utility and Intrinsic Values for Math

Mean-level changes in boys and girls' utility and intrinsic values for math across Grades 8, 9 and, 10 were as follows: Both groups showed decreases in their utility values for math across and after the transition to high school, whereas only boys showed declines in their intrinsic values for math. Contrary to what we expected, no gender differences were found in students' perceptions of the usefulness of math.

Given the positive relation between students' math competence beliefs and values for math, coupled with our findings regarding mean-level declines in math competence beliefs, it was not surprising to find a similar pattern for math values. The likelihood that students

come to value tasks at which they believe they are competent, reflecting a direction of causality from competence beliefs to values (e.g., Lopez, 1997), helps us to understand why we are seeing parallel mean-level declines in students' values for math across and after this same transition period. It is believed that when students experience negative changes in their math competence beliefs (as is true for our sample), they may lower their value ratings for math in response, in order to protect their self-esteem (Fredricks & Eccles, 2002; Steele 1988; Wigfield & Eccles, 1992; Wigfield, Eccles, Harold, et al., 1997).

The mean-level decreases in students' utility value and in boys' intrinsic value for math that were found in our study are consistent with results of past research. Within the extant literature, the overall pattern of change in students' mean-level competence beliefs and values for math (utility, importance, and intrinsic) is one of decline across the later elementary and early high school years (Eccles et al., 1989; Gottfried, Fleming, & Gottfried, 2001; Wigfield et al., 1991; Wigfield et al., 1997). When students make the transition to high school, they move to an increasingly extrinsic learning environment. The same adverse effects of this environment on student's math competence beliefs pertain to students' values for math. For example, increased competition, social comparisons, and ability groupings, and decreased personalized attention in the high school learning environment all contribute to negative changes in students' achievement-related competence beliefs and values. In a subject area like math, which students perceive to be more difficult and require more effort relative to other subject areas, the negative effects may be even more pronounced.

In our study, we found no significant gender differences in the mean-level of students' valuing of math across Grades 8, 9 and 10. Although gender differences

favouring high school boys in math utility value have been reported in earlier studies (Eccles, 1983; Hyde et al., 1990; Hyde, Fennema, et al., 1990), results of more recent research found no such gender differences in students' subjective task values for math (Fredricks & Eccles, 2002; Gottfried et al., 2001; Simpkins et al., 2006). For example, Fredricks and Eccles (2002) found that, although boys had significantly higher value ratings for sports than did girls, no gender differences were found in their value ratings for math.

Even with no significant gender differences in students' mean-level valuing of math in the present study, it is interesting that girls' intrinsic value for math did not decrease across Grades 8, 9, and 10, whereas it did for boys. This finding may be better understood when we consider research in the related but not identical area of motivation. It has been found that girls' orientation to school work and to math in particular is more mastery based than that of boys. Intrinsic motivation is characterized in part by a mastery orientation to learning. In a study described earlier, Bong (2005) provided important information in understanding how girls' intrinsic motivation is affected by changes they perceive in their academic environment when making the transition to high school. Specifically, she found that teenage girls neither increased their use of performance-approach goals nor reduced their personal mastery orientation when it came to math, even though they perceived their high school learning environment to be more performance based. It may be that when girls hold on to their mastery learning approach in math, their intrinsic motivation for math is not greatly affected by changes in their perceptions of the math environment as being performance-based. As intrinsic motivation and intrinsic valuing of math are somewhat related, the same logic may be helpful in understanding why girls in our sample showed no

decrease in their intrinsic valuing of math across and after the transition to high school, whereas boys did. We present this interpretation with appropriate caution, as other researchers have found no gender differences in mean-level declines of high school students' intrinsic values for math (Eccles et al., 1989; Wigfield et al., 1991; Wigfield et al., 1997).

Stability of Utility and Intrinsic Values for Math

The constructs of utility and intrinsic values for math proved moderately stable in our study (r s averaging between .57 and .61), supporting suggestions that the stability of math values as a construct is well established by adolescence (Eccles et al., 1989; Fredricks & Eccles, 2002). Although Eccles and her colleagues found task values to be somewhat less stable than math competence beliefs during adolescence (Eccles et al., 1989), our results suggest that the two are comparable.

The stability of adolescents' utility value for math, reflecting an individual's position within a larger group, differed as a function of gender. Consistent with our hypothesis, boys' utility value for math increased in stability across Grades 8, 9, and 10. No changes were found in the stability of girls' utility value for math during this same time period. With respect to students' intrinsic values for math, no increase in stability was found across Grades 8, 9, and 10 for either boys or girls.

Whereas in our study only adolescent boys showed an increase in the stability of their utility value for math, in Fredricks and Eccles (2002) study students' perceptions of the importance/usefulness of math increased for both boys and girls beginning in Grade 10. It may be that, following the initial disruption of the transition to high school, boys in our sample showed signs of regaining their pre-transition values regarding the usefulness of

math more quickly than did girls. As discussed earlier, math is generally considered a stereotypically masculine subject area. In the context of the gender-intensification theory, it is possible that, compared to girls, boys experience more pressure to pursue advanced math and science courses in order to keep their educational and occupational options open. The increase in stability that we are seeing in boys' utility value for math may be partly reflective of these pressures and partly reflective of boys' intentions to enroll in math-related courses and occupational fields. Although the gender gap in high school math enrolment is narrowing, men have been found to still outnumber women in traditionally masculine fields (US Department of Education, 2003).

Although many possibilities exist for why we are not seeing an increase in the stability of girls' utility value for math, the answer may well lie in the timing of our study. It may be that we would have seen an increase in the stability of girls' utility value for math as we saw with boys if we extended the timeframe of our study to include Grades 11 and 12. With considerable efforts being made to encourage girls to continue taking higher level math courses, more girls are remaining in the math stream. It may be that the effects of such efforts will become more apparent in the upper high school years when making choices about their math involvement is more salient.

Summary of Math Competence Beliefs and Math Values

Knowing about mean-level changes and the stability of students' math competence beliefs and values for math provides us with salient information about their continuity and predictability and is helpful in informing educational practice. Table 18 below is illustrative of the practicality of our results. Specifically, by considering students' pre-transition levels of math competence beliefs and values for math, as well as changes in the

stability of these variables across and after the transition to high school, we are able to outline different trajectories students may follow. Such information is helpful in identifying students who may be most at risk regarding their post-transition levels of the variables in question. From Table 18, we see that students may fall into one of four scenarios as they make the transition to and across high school. Students who have low pre-transition levels of math competence beliefs and/or values for math are initially at some risk of experiencing difficulty across this period. However, their outcomes will depend in part on whether or not the stability of their math competence beliefs and values for math increases or decreases. If stability increases, those students are most at risk because they will likely retain their pre-transition low position level relative to their group of peers. Additionally, knowing that there exist declines in the mean levels of students' math competence beliefs and values for math across this time period, it is probable that these students, who already have low levels of these variables, will have even lower post-transition levels. If the variable stability decreases on the other hand, these students may change their low level position within their peer group. As such, there is the potential for change and, through work students may change to higher levels of math competence beliefs and values for math across and following the transition to high school.

Table 16

Hypothetical Variable Trajectories Across and After the Transition to High School

Pre-transition Variable Levels	Stability	Description of Risk Level level
Low Math competence beliefs and/or values for math	Increasing	High risk students who will likely have very low post-transition levels of variable in question.
	Decreasing	Students are at some risk because of pre-transition low levels of variable. However, there is the potential for change and improvement as indicated by the decreasing stability of the variable in question.
Moderate / High Math competence beliefs and/or values for math	Increasing	Low risk students who will likely retain their moderate to high pre-transition levels of variable in question.
	Decreasing	Students may be at risk because they will possibly not retain their pre-transition levels of the variable in question. Level of risk will be related to magnitude of drop they experience over this particular time period.

Students with moderate to high pre-transition levels of math competence beliefs and values for math are at partial risk if the stability of these variables decreases across and after the transition to high school. Specifically, if variable stability decreases, these students will possibly not retain their high pre-transition position within the group. Their risk level in terms of their post-transition levels of math competence beliefs and values for

math will then depend on the magnitude of decline they experience in these variables across and after the transition to high school.

When taken together, our results regarding mean-level changes and stability correlations of students' math competence beliefs and values for math across and after the transition to high school provide a more complete understanding of the continuity of these constructs, which in turn is be useful in informing educational practice.

The Continuity of Math Performance and Math Enrolment Intentions

Mean-level Changes in Math Performance

Mean-level changes in students' math performance revealed a main effect for time, such that adolescents' math grades decreased significantly from Grades 8 to 9, but not from Grades 9 to 10. This finding supported our hypothesis.

With the general disruption of the transition to high school, including the novelty of a new school, new teachers, and especially a different evaluation system, it is understandable that there would be a mean-level drop in students' math grades from Grades 8 to 9. Students' math performance may be more affected by this disruption given that math is already endorsed as a more difficult subject requiring more effort relative to other academic areas. Researchers have consistently found declines in math performance across the transition to high school. For example, Seidman and his colleagues found that the declines in students' GPA associated with the transition to high school were common across gender and ethnicity (Seidman et al., 1994).

Gender differences favouring girls in classroom math performance are frequently reported in the literature (e.g., Kenney-Benson et al., 2000; Sommers, 2000). The positive association and cyclical nature of the relation between math performance and math

competence beliefs also helps explain our findings. Specifically, our results reveal mean-level declines in both. Although one would assume that students' math competence beliefs would directly reflect their math performance (in direction and in magnitude), it has been suggested that boys tend to overestimate their ability in math, whereas girls generally underestimate their ability (Kenney-Benson et al., 2006). In our study, despite their lower math competence beliefs, girls had higher math grades than did boys across Grades 8, 9, and 10 on average. With no shortage of explanations to account for their sometimes higher math grades, researchers have suggested that girls' edge over boys may be due in part to: Their approach to schoolwork (Schunk & Zimmerman, 1994), teachers' bias perceptions regarding behaviour in the classroom (Bennett, Gottesman, Rock, & Cerullo, 1993), (3) increased parental monitoring of girls (Bumpus, Crouter, & McHale, 2001), and (4) biological processes (Campbell & Eaton, 1999).

Even with girls' comparable and sometimes superior math performance to boys, we are still faced with their lowered levels of math competence beliefs, relative to boys and also relative to their objective math performance and ability. As such, efforts are required to help reduce the gap between girls' objective math performance and their perceptions of their math ability. As grades and competence beliefs are positively associated, efforts to increase one will have a secondary effect on the other. Encouraging early involvement in math-related activities and ensuring that girls' experiences of these activities are positive may be one worthwhile intervention. Another means to help girls interpret their math performance more accurately, and thereby increase their math competence beliefs so as to reflect their math performance, would be to is to demystify the area of mathematics as a "masculine" subject area. The findings of two recent studies by Schmader and colleagues

are compelling (Schmader, Johns, & Barquissau, 2004). In their first study involving women majoring in math-related fields, they found that those who believed the legitimacy of gender status differences favouring men in math themselves endorsed gender stereotypes about women's math abilities and reported being less interested in pursuing their own studies in their respective math-related fields. Their second study involved women who were not majoring in math-related fields and endorsed gender stereotypes favouring men. They found that these women, as compared with those who did not endorse gender stereotypes in math, were more susceptible to the negative effects of the "stereotype threat" on their math performance. In other words, simply believing the legitimacy of gender status differences favouring men in math has a negative effect on women's math performance. With active efforts to reduce girls' perceptions of math as a more masculine subject area and to emphasize their existing comparable math grades to boys, the gender gap in math competence beliefs found in the present study may begin to narrow.

Stability of Math Performance

Contrary to what we expected, there was no increase in the stability of students' math performance across and after the transition to high school. Given that the stability of students' math grades in the present study was in the moderate range and that there was no increase (or decrease) in this stability across Grades 8, 9, and 10, it is reasonable to expect that there will be some variability in students' positions within their larger peer group. From this information, and coupled with our results regarding declines in the mean-levels of math grades, it is very likely that some students will experience negative changes in their math performance across and after the transition to high school, and that the magnitude of the decline experienced by a student will in part determine a student's position relative to

others after the transition to high school. Taken together, given that the stability of math grades in our study was moderate and did not increase, we can expect some variability in students' math performance across and after the transition to high school. As such, consistent and continual efforts to increase students' performance in math across and after the transition to high school would appear to be effective in helping reduce the negative changes associated with this period.

Mean-level Changes in Math Enrolment Intentions

Contrary to what we predicted, there was a mean-level increase in students' math enrolment intentions across Grades 8, 9, and 10. Girls were found to report higher math enrolment intentions than boys across Grades 8, 9, and 10 on average. We had expected to find a decrease in students' intentions to enroll in future math courses because we anticipated that the declines in math grades, competence beliefs, and values for math typically associated with the transition to high school period would carry over to negatively affect math enrolment intentions as well. Although one may interpret our results as suggesting otherwise, it could be that asking students about their intentions to enroll in future math courses at a time when enrolment in math is still mandatory for them is not within what they can readily imagine. Should this be the case, it is possible that we would see a different pattern emerging in Grades 10, 11, and 12, when enrolling in different and upper level math courses becomes optional. Reporting bias could be another possible explanation for the mean-level increase in students' math enrolment intentions. Specifically, students new to the high school environment may have a high need to appear solid and confident in their intentions to pursue math in the future.

Our results pertaining to girls' higher math enrolment intentions relative to boys' across Grades 8, 9, and 10 may be reflective of the narrowing gender gap in high school math enrolment. It also may be suggestive of the positive effect of efforts aimed at encouraging and promoting girls' involvement in math.

Finally, it is important to keep in mind the distinction between math enrolment intentions and actual math enrolment. Obtaining records of the latter would be helpful in assessing true enrolment and in assessing the relation between students' intentions and their actual enrolment behaviour.

Stability of Math Enrolment Intentions

Contrary to what we hypothesized, there was no decrease in the stability of students' math enrolment intentions across and after the transition to high school. With only the moderate to low stability ($r = .40$, on average) found in our study, it is probable that many students will not retain their relative positions (low, medium, or high) across and after the transition to high school. This may not altogether be negative. For example, in combination with a mean-level increase in students' intentions to enroll in future math courses, many students who may have been in the low or medium ends of the class regarding their math enrolment intentions will likely move up in their relative positions. However, because of the low to moderate stability of students' math enrolment intentions and no change in this across and after the transition to high school, other students will move down on the scale relative to their peers. The expected variability in students' math enrolment intentions relative to others suggests that students can change given the right kind of environment. Educating students about the usefulness and importance of math for keeping their educational and occupational options open would likely be helpful. In

promoting this awareness, it may be useful to provide examples of students' who prematurely dropped out of the math stream and later decided to pursue an educational career requiring math. It may be that the impact of relevant and concrete examples would be greater than abstract and didactic reasoning for certain students and for certain age groups.

Summary and Conclusion of Part 1

As measures of continuity, we looked at mean-level changes and stability correlations of students' math competence beliefs, values for math, math performance and math enrolment intentions across and after the transition to high school period. With the exception of math enrolment intentions, we expected to find mean-level decreases and an increase in the stability of each of these variables across Grades 8, 9, and 10. Our hypotheses, grounded in theoretical and empirical support, were based on two main assumptions. First, we expected mean-level declines in these variables because the transition to high school timeframe is a period of disruption, creating a disequilibrium that has negative effects on students' math-related performance, beliefs, and values. Second, we expected an increase in stability of these variables by Grade 10 knowing that, to varying degrees, students will adapt to the high school environment and show some level of re-stabilization.

In general, and again with the exception of math enrolment intentions, our results regarding mean-level changes provide corroborating evidence for the general declining pattern in students' math-related performance, competence beliefs, and values found by other researchers. Our hypotheses regarding increases in the stability of students' math performance, math competence beliefs, and values for math were largely not supported

within the timeframe of the present study. With the exception of boys' utility value for math, we saw no increase in the stability correlations of any of the variables across and after the transition to high school. Our results lead us to two important directions for future research.

First, recalling that our hypotheses were developed based on the assumption that some students will re-stabilize once they have adapted to the high school environment, we believe that the accuracy of these assumptions remains valid. It is possible that the reason we are not seeing any increase in the stabilization of these variables is because we have not allowed sufficient time for students to adapt to the high school environment. As mentioned earlier, we believe that extending the current study to include Grades 11 and 12 will provide a reasonable timeframe within which to allow for the occurrence of any significant re-stabilization. Research documenting increases in the importance of math beginning in Grade 10 (Fredricks & Eccles, 2002) and related studies suggesting an increase in intrinsic motivation for math beginning around the same time (Gottfried et al., 2001) lend support for this reasoning. In addition, results of the present study revealed an increase in the stability of boys' utility value for math as they moved into Grade 10. Taken together, it is possible that an increase in stability of students' math competence beliefs, values for math, and math performance will occur, given a lengthier post-transition period.

Second, in addition to extending the post-transition timeframe of the present study, including more pre-transition years (e.g., Grade 6 and 7) would enable us to determine whether the mean-level variable decreases we found are part of the general decline that begins somewhere in elementary school or whether the pattern we are seeing is an additional decline associated specifically with the disruption of the transition to high school

period. For example, we do not know if the pattern of decline in math performance, math competence beliefs, and values for math is consistent in magnitude across time or whether it accelerates during the transition to high school period. Having two additional pre-transition years on which to base mean-level changes and stability correlations would further our understanding of the trajectory of change for each of the variables in our study.

In summary and at a practical level, the mean-level declines found in the present study, coupled with the lack of increases in the stability of students' math-related performance, competence beliefs, and values, suggest that remedial and preventative interventions need to begin early and be continuous. With only moderate levels of stability, we know that the students who need help at one point in time will not necessarily be those who need that help at a different point in time. Thus, many students could benefit from active efforts to increase math-related competence beliefs and values at various points along the educational continuum.

Parts 2 and 3

Parts 2 and 3 of the current study are a first time examination of the role of change (in math competence beliefs and values) in predicting adolescents' math performance and math enrolment intentions across and after the transition to high school. Whereas many studies have confirmed the existence of mean-level declines in students' math competence beliefs and values, none has examined the direct effect of these changes themselves in the prediction of students' math performance and math enrolment intentions. The present study is the only one that we know of to date that has examined empirically the predictive role of change in students' math competence beliefs and math values on their math performance and math enrolment intentions across and following the transition to high school period.

The longitudinal models tested in the current study synthesize previous research on mean-level changes in students' math-related competence beliefs, values, performance, and enrolment intentions, as well as research on the relations among these variables.

In Parts 2 and 3, the main objectives were to (1) assess the direction of causality between math competence beliefs and values for math, (2) provide support for key relations between math competence beliefs, values for math, math performance, and math enrolment intentions outlined in Eccles' expectancy-value model, and (3) examine the differential predictive influences of changes in math competence beliefs and values for math across and after the transition to high school on adolescents' short- and longer-term math performance and math enrolment intentions. Part 2 of the current study concerned changes that occurred in students' math competence beliefs across the transition to high school, from Grades 8 to 9. Part 3 of the current study concerned changes that occurred in these same variables after the transition to high school, from Grades 9 to 10.

Why Look at Change?

Without looking at the predictive role of change, the impact of the declines associated with the transition to high school period on students' math performance and math enrolment intentions is not being assessed fully. There is a proliferation of research documenting negative changes in students' math-related competence beliefs and values across and following the transition to high school. Our study provides support for those findings, in that students in our sample showed this same declining pattern in their mean-level math competence beliefs and math values across Grades 8, 9, and 10. Given the occurrence of such negative changes, it would be useful to examine the influence of these changes. However, to date, conclusions about the predictive effects of negative changes in

students' math competence beliefs and values for math have been based predominantly on the knowledge that math competence beliefs and values are correlated with math performance and math enrolment intentions. It has been deduced that since beliefs and values are associated with performance and enrolment intentions, then negative changes in these beliefs and values will in turn produce negative changes in performance and enrolment intentions. Although logical, such reasoning is not without limitations. For example, we do not know if the negative changes that are occurring in students' math competence beliefs and math values have an actual effect in predicting their math performance and math enrolment intentions. In a recent study examining intrinsic and extrinsic motivational changes, the authors wrote, "Most researchers have treated a decline in motivation as a negative consequence that should be avoided because a low level of motivation has been negatively associated with a successful pursuit of studies. However, those researchers did not examine whether the actual decline in motivation was associated with specific consequences" (Otis, Grouzet, & Pelletier, 2005).

The same can be asked about changes in math competence beliefs and values for math. Without direct empirical support, the validity of drawing conclusions about the predictive effects of the declines in students' math competence beliefs and math values based on the results of models that have not incorporated change scores remains limited. Knowing about the predictive effects of the changes in students' math competence beliefs and values across and after the transition to high school would inform researchers and educators about the importance of developing intervention and prevention programs to lessen some of the negative effects associated with this period. The present study's results pertaining to changes in math competence beliefs and values for math across the transition

to high school will be addressed following a discussion of the relations between the variables included in our model.

Model 1: Support for the Hypothesized Key Relations between Variables Outlined in

Eccles' Model

The focus of this section is on support for the examined relations between students' pre-transition (Grade 8) math performance, math competence beliefs, and values for math and their post-transition (Grade 9) math performance and math enrolment intentions.

Grade 9 Math Grades

In the present study, both boys and girls' pre-transition (Grade 8) math grades and math competence beliefs predicted directly their post-transition (Grade 9) math grades. Our results concerning these relations support those of other studies. Specifically, the reciprocal relation between math grades and math competence beliefs is well-founded in the literature (Casey, Nuttall, & Pezaris, 1997; Crombie et al., 2005; Frome & Eccles, 1998; Valentine, et al., 2004). It is believed that the feedback (e.g. grades) students receive about their math performance influences their perceptions of their math ability such that more positive feedback is associated with higher math competence beliefs (e.g. Parsons [Eccles] et al., 1984; Simpkins et al., 2006). Students' beliefs about their mathematical ability, in turn, influence their subsequent math achievement. The stronger students' beliefs are about their competence in math, the more confident they will be about their ability to achieve and hence the more likely they will be to do well in math. Given this cyclical relation, it is not surprising that students' Grade 8 math grades and math competence beliefs had direct effects on their Grade 9 math grades. In a recent meta-analytic review of the relation between beliefs and academic achievement in prospective investigations, Valentine and his

colleagues concluded that competence beliefs consistently predict academic achievement, even after controlling for initial levels of achievement (Valentine et al., 2004). They also found that the estimated effect size of the relation between beliefs and academic achievement is stronger when measures are specific to a certain domain (e.g., math or science).

It is interesting to note that, despite the consistency across gender of the relational paths among these variables, boys had overall higher math competence beliefs than girls and girls had overall higher math grades than boys across Grades 8, 9, and 10. The fact that girls underestimate their math ability as compared to boys, even when they outperform boys on math achievement measures, is a finding that is generally found in the literature (Heller & Ziegler, 1996; Herbert & Stipek, 2005; Juang & Silbereisen, 2002) (see Part 1 for lengthier discussion).

Grade 9 math enrolment intentions

The direct effects of students' pre-transition (Grade 8) variables on their Grade 9 math enrolment intentions differed by gender. Girls' Grade 9 math enrolment intentions were predicted directly by their pre-transition math competence beliefs and intrinsic value for math. For boys, math enrolment intentions in Grade 9 were predicted directly by their Grade 8 math grades and utility value for math.

Gender differences regarding the link between math competence beliefs and math enrolment intentions are mixed. Results pertaining to the positive association between girls' math competence beliefs and their math enrolment intentions in our study are findings that are supported by the results of other researchers as well. For example, both Ethington (1991) and Crombie and her colleagues (2005) found a direct relation between

math competence beliefs and math enrolment intentions for girls but not for boys. On the other hand, some researchers found no gender differences in the association of these variables. For example, Simpkins and her colleagues found that math competence beliefs predicted both boys and girls' math enrolment during adolescence, beyond the predictive effect of their achievement, their parents' education, and their family income (Simpkins et al., 2006). There is also some suggestion of gender differences in the strength of the association between math competence beliefs and math enrolment intentions. Specifically, Trusty and colleagues found self-perceptions of ability in math to be stronger predictors of math enrolment intentions for boys than for girls (Trusty 2002; Trusty & Ng, 2000). With mixed results, more research is needed to clarify gender differences in the association between math competence beliefs and math enrolment intentions.

The finding that utility value for math in Grade 8 directly predicted Grade 9 math enrolment intentions for boys but not for girls, may reflect in part traditional socialization practices and related expectations held for boys. With math having been considered a male sex-typed domain, boys have traditionally been expected to pursue their education in this domain further than have girls. The direct influence of utility value for math and prior math grades on their Grade 9 math enrolment intentions may reflect boys' responses to the emphasis put on math grades and advanced math courses by college and university admittance boards (Simpkins et al., 2006).

In contrast to boys, it was girls' pre-transition intrinsic value, rather than their pre-transition utility value for math, that directly predicted their Grade 9 math enrolment intentions. As such, girls who show a high intrinsic valuing of math before making the transition to high school are more likely to continue taking math courses in high school

than girls who have low levels of intrinsic values for math interest. These results are consistent with previous related research in the area of intrinsic motivation. Studies have found that girls hold a more mastery and less performance based orientation to learning than do boys (Patrick et al., 1999; Ryan & Pintrich, 1997). When it comes to the subject area of math, researchers have found that even when girls perceive their learning environment to be more performance-based, they neither increased their use of performance-approach goals nor reduced their personal mastery orientation (Ablard & Lipschultz, 1998). With a mastery-orientation approach to work being associated with intrinsic motivation and with intrinsic motivation being a predictor of educational aspirations (Otis et al., 2005), it is likely that girls' intrinsic valuing of math would also play a significant role in any decisions they would make about future math enrolment.

It is important to keep in mind that we measured students' intentions to enroll in future math courses and not their actual enrolment. According to the theory of reasoned action, it is believed that behaviour is influenced by behavioural intention (Chiou, 2000). In other studies, the link between students' perceptions of the importance/usefulness of math and their actual enrolment in high school math courses was reported. For example, Simpkins and colleagues found that the number of high school math courses taken by students was predicted by both their math self-concept and their math values (Simpkins et al., 2006). Whether one measures math enrolment intentions or actual math enrolment, students' valuing of math appears to be one of the important predictors of students' future math involvement.

Model 1: The Influence of Changes in Math Competence Beliefs Across the Transition to High School

The occurrence (Part 1) and influence of (Part 2) changes in math competence beliefs and values for math were examined in the present study. With respect to the latter, we found that changes in math competence beliefs from Grades 8 to 9 directly predicted boys and girls' Grade 9 math performance and girls' Grade 9 math enrolment intentions. As such, the declines students experienced in their math competence beliefs across the transition to high school (Grades 8 to 9) had a direct and negative influence on their Grade 9 math grades and on girls' Grade 9 math enrolment intentions. Interestingly, changes in girls' math competence beliefs across the transition to high school (Grades 8 to 9) were stronger predictors of their Grade 9 math grades and Grade 9 math enrolment intentions than were their pre-transition Grade 8 levels of math competence beliefs. For boys, the changes they experienced in their math competence beliefs across the transition to high school (Grades 8 to 9) predicted their Grade 9 math grades with comparable strength to, but independent of, the predictive effect of their Grade 8 math competence beliefs.

Given the significance of these predictive paths, the influence of students' pre-transition Grade 8 math performance on their post-transition Grade 9 math performance occurred directly, as well as indirectly, through changes in their math competence beliefs from Grades 8 to 9. An indirect effect of Grade 8 math grades through changes in math competence beliefs from Grades 8 to 9 also occurred for girls' Grade 9 math enrolment intentions. In other words, the effects of girls' Grade 8 math grades on their Grade 9 math enrolment intentions occurred indirectly through the changes they experienced in their math competence beliefs from Grades 8 to 9.

For both boys and girls, changes in math competence beliefs from Grades 8 to 9 also predicted directly changes in their utility and intrinsic values for math across this same period. In addition to a direct effect, changes in students' math competence beliefs from Grades 8 to 9 indirectly predicted changes in their intrinsic value for math via changes in their utility value for math over this same time period. Based on our results concerning the change variables alone, we cannot conclude with full certainty that the direction of causality runs from changes in math competence beliefs to changes in values for math. In our models, we did not test paths from changes in students' utility and intrinsic value for math to changes in their math competence beliefs. Based on previous research, we incorporated paths from changes in math competence beliefs to changes in the two values for math and hypothesized that the model would fit the data well. From our results, we can conclude that changes in math competence beliefs from Grades 8 to 9 directly and strongly predict changes values for math over this same time period for both boys and girls. Future research is needed to test the bi-directionality of the influence of the changes in these variables.

Due to the lack of existing studies incorporating change variables and studies looking at the predictive role of declines in math competence beliefs and values for math across the transition to high school, we are unable to compare our results with those of other researchers. However, in looking at the significant paths to and from changes in math competence beliefs in our model, our results support the congruency of the pattern of relations found among these variables in prior studies (in which change scores have not been incorporated). Specifically, the predictive relations from math competence beliefs to

math performance and to girls' math enrolment intentions were supported in the present study, in terms of the effects of both the pre-transition variables and the change variables.

Model 1: The Influence of Changes in Values for Math Across the Transition to High School

The negative changes students experience in their values for math across the transition to high school (Grades 8 to 9) are important predictors of their subsequent math enrolment intentions. In the present study, both boys and girls' Grade 9 math enrolment intentions were directly predicted by the changes they experienced in their perceived usefulness of math across the transition to high school. For boys, the effects of these changes were stronger than the effects of their pre-transition (Grade 8) perceptions of the usefulness of math. For girls, although their pre-transition Grade 8 intrinsic value, and not their utility value, for math in Grade 8 was predictive of their Grade 9 math enrolment intentions, it was the changes they experienced in their utility value (and not their intrinsic value across the transition to high school (from Grades 8 to 9) that also directly predicted their Grade 9 math enrolment intentions.

It may be that the central role of both boys and girls' perceptions of the usefulness of math is reflective of their increased awareness of the competition of getting into college and university programs. The predictive role of changes in students' utility value for math across the transition to high school on their Grade 9 math enrolment intentions may also be reflective of the timing of their studies. In elementary school, decisions about future math enrolment may seem far off for students. At this stage, course enrolment is prescribed by the school, with math courses being mandatory at every grade level. Once in high school, the need to consider the usefulness of certain courses over others may be more salient than

it may have been in earlier years. Course selection becomes an option beginning in Grade 10, at which point students need to make decisions about pursuing standard or advanced courses in certain subject areas, including math. At this point, students become first-time decision makers about their educational paths and school guidance counsellors are made available to assist. Through this process, students' awareness about the importance and usefulness of math is undoubtedly increased.

In terms of other direct effects, changes in students' utility value for math from Grades 8 to 9 predicted directly changes in their intrinsic valuing of math across this same time period. Specifically, the negative changes in boys and girls' perceptions of the usefulness of math across the transition to high school directly predicted negative changes in their intrinsic value for math at this same time, beyond the direct effect of changes in their math competence beliefs from Grades 9 to 10.

With respect to indirect effects, for boys in our study, pre-transition (Grade 8) math competence beliefs indirectly predicted their post-transition (Grade 9) math enrolment intentions via changes in their utility value for math from Grades 8 to 9. In other words, the effects of boys' Grade 8 math competence beliefs on their Grade 9 math enrolment intentions occurred indirectly through the changes they experienced in their utility value for math across the transition to high school. For girls, although there were indirect effects of Grade 8 math competence beliefs on Grade 9 math enrolment intentions, none occurred directly through changes in their math task values from Grades 8 to 9. For example, the indirect influence of girls' Grade 8 math competence beliefs on their Grade 9 math enrolment intentions occurred through their Grade 8 math grades to changes in their math

competence beliefs from Grades 8 to 9 to changes in their utility value for math from Grades 8 to 9.

Once again, the lack of research incorporating change variables makes comparing our results with others not possible. However, our results pertaining to the effects of students' pre-transition values for math and of the changes they experience in their values across the transition to high school support the pattern of relations between values for math and math enrolment intentions found in previous studies. Furthermore, the changes boys experienced in their utility value for math from Grades 8 to 9 was a stronger predictor of their Grade 9 math enrolment intentions than was their pre-transition Grade 8 utility value. For girls, changes in their math utility value from Grades 8 to 9 significantly and directly predicted their Grade 9 math enrolment intentions, whereas their Grade 8 utility value for math did not. With stronger effects from changes in math values than from pre-transition Grade 8 math values, our results suggest that interventions aimed at reducing some of the negative effects associated with the transition to high school in this respect will have a positive influence on girls' and boys' math enrolment.

Model 1: Direction of Causality between Math Competence Beliefs and Values for Math

In the present study, the direction of causality between math competence beliefs and values for math was assessed by including the following paths in Model 1: From students' Grade 8 math competence beliefs to changes in their utility and intrinsic values for math from Grades 8 to 9 and from students' utility and intrinsic values for math in Grade 8 to changes in math competence beliefs from Grades 8 to 9. Consistent with prior research, our primary hypothesis was that students' Grade 8 math competence beliefs would predict changes in their two values for math from Grades 8 to 9. However, as a less

likely alternative hypothesis, we also tested the paths from the two values for math to changes in math competence beliefs from Grades 8 to 9.

Consistent with our main hypothesis, for boys, results indicate that math competence beliefs in Grade 8 directly predicted changes in both their utility and intrinsic values for math from Grades 8 to 9. For girls, no significant effects were found in either direction. In other words, no significant predictive paths were found from their Grade 8 math competence beliefs to changes in values for math from Grades 8 to 9 or from their Grades 8 values for math to changes in their math competence beliefs from Grades 8 to 9. Based on our results for boys, there is some suggestion that the direction of causality runs from math competence beliefs to values for math. Although there is no support for either direction of causality in these results for girls, we do know that the changes girls experienced in their math competence beliefs from Grades 8 to 9 were directly predictive of changes in their values for math over this same time period. In fact, the pattern of relations from changes in math competence beliefs to changes in utility and intrinsic values for math was similar for boys and girls. Specifically, when students' beliefs about their math competence decrease (as occurs across the transition to high school period), they show negative changes in both their perceptions about the usefulness of math and their intrinsic value of math.

It may be that students lower their values for math in the face of decreased math competence beliefs in order to protect their self-esteem. For example, if students put forth the image that they do not care about math (that they are not interested in it or that it is not useful), then not doing well in it is less of a threat than it would be had they have maintained a higher level of utility and intrinsic value. Changes in math competence beliefs

across the transition to high school accounted for the majority of the variance explained by the model in changes in students' utility value for math. In combination with the effects of changes in students' utility value for math, changes in math competence beliefs across the transition to high school also accounted for a significant portion of the explained variance in changes in boys and girls intrinsic value for math.

This pattern of relations between the constructs alone (not in the changes in the constructs) has been supported by previous researchers (e.g., Lopez, 1997). By way of explanation, as mentioned above, it is believed that students come to value those tasks (or subjects) on which they believe they are competent. Conversely, to protect their self-esteem, students may lower the value they attach to a particular task when they do not believe they are competent in it. Having examined the relations among changes in these variables, results of the present study provide support for and extend prior research in this area.

Changes in Math Competence Beliefs and Values for Math, and Variable Stability

The stability measures examined in Part 1 of the current study provide a context within which we can better understand how students' pre-transition (Grade 8) levels of math competence beliefs and values for math and the changes they experience in these variables across the transition to high school complement each other and help predict how students will fare in terms of their post-transition (Grade 9) math performance and math enrolment intentions. Recall from Part 1 that stability correlations provide us with information about the cross-time stability of an individual's position within the group (Gottfried et al., 2001; Lightfoot & Folds-Bennett, 1992), helping us determine if students

who begin at the low, middle, or high ends of the group in their math competence beliefs will remain in those similar positions relative to the larger group over time.

Math Competence Beliefs

The stability of boys' math competence beliefs in the present study was in the moderate range and did not change across Grades 8, 9, and 10. Girls' math competence beliefs, although initially moderate, decreased across this same time period. Had we found that the stability of students' math competence beliefs increased across Grades 8, 9, and 10, we would have been able to say, with reasonable confidence, that students who were at the higher end of the scale in terms of their math competence beliefs before making the transition to high school would likely be on the higher end of this same scale following the transition to high school (and vice versa for students on the lower end of the scale). The fact that we found no increase in the stability of boys' math competence beliefs and a decrease in the stability of girls' math competence beliefs across the transition to high school leads us to conclude that there will be a certain degree of variability in a student's position relative to their peers from their pre-transition Grade 8 year to their post-transition Grade 9 year (expecting more variability for girls than for boys). Specifically, we can expect that some students who are at the low, middle, or high ends of the group in their math competence beliefs in Grade 8 will not retain these same positions following the transition to high school, with this being more true for girls than for boys.

In this respect, knowing about students' pre-transition (Grade 8) levels of math competence beliefs alone is not enough to determine which students will be most at risk in this area following the transition to high school period. For example, because of the decrease in stability of girls' math competence beliefs, we cannot say with any degree of

certainty that girls who are at the lower end of the group in their math competence beliefs in Grade 8 are the only ones who are at risk during the transition to high school period. We also need to look at the changes youth experience in their math competence beliefs across the transition to high school, paying particular attention to those who show large drops in their levels of math competence beliefs. Given that our results show a direct predictive relation from changes in math competence beliefs to students' Grade 9 math performance and to girls' Grade 9 math enrolment intentions, interventions need not only target students' who have low pre-transition levels of math competence beliefs, but also and equally important, those who show the greatest declines as they make the transition into high school.

Values for Math

The stability of boys' values for math was initially moderate and subsequently increased. Specifically, the stability correlation of boys' utility value for math from Grades 9 to 10 was stronger than it was from Grades 8 to 9. This means that, when it comes to their perceived usefulness of math, a boy's relative position on the value continuum becomes more predictable as he progresses through to Grade 10. As such, boys who are at the higher end of the continuum regarding their utility value for math when making the transition to high school are more likely to remain at the higher end of this continuum two years into high school. Conversely, boys who do not see math as particularly useful at the time of the transition are more likely to retain those same low levels of utility value for math into Grades 9 and 10. For this reason, it becomes that much more important to target the transition to high school year as a critical period for intervention. If the negative changes boys' experience in their utility value for math across the transition to high school can be

minimized, and ideally reversed (experience a positive change), more boys will be at a higher level of the utility value continuum at a time when such values may become increasingly stable. The result of which, given the link between changes in boys' utility value for math and their math enrolment intentions, will be a greater likelihood of math enrolment for these boys in the upper high school years.

For girls, our results showed no increase in the stability of utility value for math across Grades 8, 9, and 10. Again, with an existing moderate level of stability, we know that a certain proportion of girls who hold high, medium, and low levels of values about the usefulness of math will not necessarily retain the same relative positions across the high school years. Given that a certain degree of variability of position can be expected, intervention programs aimed at reducing the negative effects of the transition to high school period on girls' values for math is important. Since the changes girls experience in their utility value for math across the transition to high school (from Grades 8 to 9) are directly predictive of their math enrolment intentions (in Grade 9), efforts to reduce the negative effects of the transition to high school on their values will translate into greater intentions to enroll in subsequent math courses.

Who is at Risk?

The current study is informative in understanding some of the predictive effects of the negative changes in students' math competence beliefs and values for math associated with the transition to high school. Specifically, the changes students experienced in their math competence beliefs across the transition to high school (from Grades 8 to 9) directly predicted, beyond the effects of their pre-transition Grade 8 math competence beliefs, their Grade 9 math grades and girls' Grade 9 math enrolment intentions. Also, the changes

students experienced in their utility value for math across the transition to high school (Grades 8 to 9) predicted directly their Grade 9 math enrolment intentions. For boys, this effect was greater in magnitude than the predictive effect of their pre-transition utility value for math. Given these predictive relations, our results indicate that the declines students experience in their math competence beliefs and values for math across the transition to high school have direct and negative effects on their post-transition math performance and math enrolment intentions. As such, students who are most at risk for poor math performance and low math enrolments in Grade 9 are those who show the greatest drops in their math competence beliefs and values for math across Grades 8 to 9.

Although such information is useful in identifying areas of intervention (e.g., math competence beliefs and values for math), our results provide us with little information about what factors predict the negative changes in math competence beliefs and math values across the transition to high school. Given the predictive relations from beliefs to values, we know that efforts to reduce the negative changes in students' math competence beliefs across the transition to high school will likely have a similar positive effect on their values for math across this same time period. However, we are limited in our understanding of factors that predict changes in math competence beliefs across the transition to high school. From our results, we know what variables are predicted by the changes in math competence and values for math across the transition to high school, but we do not know what variables predict changes in these variables over this time period. "Predict what?" and "Are predicted by what?" are two central questions that we had hoped to address in the present study. Although successful regarding the former question, we continue to know little about the latter.

What can be Done? Intervention Efforts

The only variable in the present study that had a direct predictive effect on changes in students' math competence from Grades 8 to 9 was their pre-transition (Grade 8) math grades. However, this predictive effect was relatively small, accounting for only 4 % and 5 % of the variances in changes in math competence beliefs for boys and girls, respectively. As such, focusing on students' Grade 8 math grades in an attempt to head off negative changes in students' math competence beliefs across the transition to high school is not sufficient, particularly for girls, since we know that they tend to underestimate their capabilities in math when rating their math competence.

By virtue of the fact that no studies have looked at variables predicting actual changes in students' math competence beliefs across the transition to high school, we cannot make any direct comparisons with previous research. However, given that students' pre-transition levels of math competence beliefs also directly predicted their Grade 9 math grades and girls' Grade 9 math enrolment intentions, one approach to reducing the negative effects of the transition to high school period on these outcome variables would be to help students build their math competence beliefs over the course of their elementary school years. The rationale behind this approach is that, the higher the students' math competence beliefs in their pre-transition year (Grade 8), the less likely they will be affected by the negative changes that do occur over the transition to high school period. This reasoning is sound and is based on empirical support for the predictive relation from students' pre-transition levels of competence beliefs to their post-transition math performance and to girls' post-transition math enrolment intentions. Based on results of previous studies, some of the approaches recommended by researchers to increase students' math competence

beliefs include increasing students' positive experiences with math and more out-of-school involvement in math-related activities (Dickhauser & Stiensmeier-Pelster, 2002; Jacobs et al., 1998), increasing parental involvement and expectations when it comes to their child's math courses (Herbert & Stipek, 2005), modifying aspects of the high school environment to better match students' learning needs (Seidman et al., 1994), and increasing teacher support to decrease perceived change across the transition to high school (Barber & Olsen, 2004). Although elaborating on each of these methods goes beyond the scope of the present study, it is possible that a combination of these could protect students against the negative changes in math competence beliefs associated with the transition to high school period. However, without incorporating change variables (be they predictor or outcome variables) into existing models, we cannot say with any degree of certainty what variables predict, and thereby can protect students against, the negative changes in math competence beliefs and values associated with the transition to high school. Specifically, although we know that students generally experience a decline in their math competence beliefs across the transition to high school period, we do not yet know how to predict which students will show the greatest drop. Further research is needed to identify and investigate factors that are predictive of the negative changes students experience in their math competence beliefs across the transition to high school period.

Summary and Conclusion of Model 1

In Model 1, we examined the predictive roles of changes in math competence beliefs and values for math across the transition to high school (from Grades 8 to 9) on students' Grade 9 math performance and math enrolment intentions. The key summary points derived from our results are presented below.

- Our results concerning the paths we tested are consistent with and provide additional support for the pattern of relations among key variables outlined in Eccles' expectancy-value model of achievement (math-related competence beliefs, values, performance, and enrolment intentions). Specifically, students' pre-transition math grades had direct and indirect effects on their Grade 9 math grades. They also predicted Grade 9 math enrolment intentions directly for boys and indirectly for girls. Pre-transition math competence beliefs were predictive of students' Grade 9 math performance and of girls' Grade 9 math enrolment intentions. Students' pre-transition values for math (utility value for boys; intrinsic value for girls) had small but significant direct effects on their Grade 9 math enrolment intentions.
- In terms of direction of causality, our results provide support for the predictive paths from math competence beliefs to values for math. Specifically, boys' Grade 8 math competence beliefs predicted directly changes in their utility and intrinsic values for math from Grades 8 to 9. Also, changes in math competence beliefs from Grades 8 to 9 predicted directly changes in utility and intrinsic values for math for both boys and girls across this same time period.
- Looking at the significant paths from the change scores, our results support the congruency of the same pattern of variable relations outlined by Eccles. Changes in math competence beliefs across the transition to high school (from Grades 8 to 9) were predictive of students' Grade 9 math performance and of girls' Grade 9 math enrolment intentions. Changes in values for math (namely utility value)

across this same period were directly predictive of students' Grade 9 math enrolment intentions.

- The predictive effects of the changes students experienced in their math competence beliefs and values across the transition to high school on the outcome variables (Grade 9 math performance and math enrolment intentions) were significant, beyond the direct effects of their pre-transition math-competence beliefs and values for math. Specifically, for boys, changes in math competence beliefs (from Grades 8 to 9) predicted their Grade 9 math performance, beyond the direct effects of their pre-transition (Grade 8) math competence beliefs. Similarly, changes in their utility value for math from Grades 8 to 9 predicted their Grade 9 math enrolment intentions, beyond the direct effects of their pre-transition (Grade 8) utility value for math. For girls, changes in their math competence beliefs from Grades 8 to 9 predicted their Grade 9 math enrolment intentions with greater strength than did their pre-transition levels of math competence beliefs.
- With the direct paths from changes in students' math competence beliefs to changes in their utility and intrinsic values for math, we have some idea of where to target efforts to reduce the negative effects of the transition to high school period on students' math values. However, we continue to have little understanding about what factors predict changes in students' math competence beliefs across this same period. With the exception of a small direct effect from students' pre-transition math grades, no other Grade 8 factor in the present study

directly predicted changes in students' math competence beliefs across the transition to high school.

The results of the present study clearly outline the importance of looking at the changes (usually declines) students experience in their math competence beliefs and values for math across the transition to high school. With significant direct effects on their high school math performance and math enrolment intentions, the declines in math competence beliefs and values typically associated with the transition to high school need to be reduced, and ideally reversed. Because our results provide some support for the direction of causality from math competence beliefs to values for math, we know that heading off negative changes in math competence beliefs across the transition to high school will have a similar positive influence on reducing the negative changes in students' values for math across this same period. However, because we know so little about what factors predict changes in students' math competence beliefs across the transition period, further research is needed before we can be efficient in our efforts to reduce some of the negative changes typically associated with this period.

Given the direct relations between pre-transition math competence beliefs and values for math on our outcome variables, we can use various methods supported by previous research to increase students' math-related competence beliefs and values before they make the transition to high school. However, without empirical research examining variables that are predictive of the changes in math competence beliefs and values for math associated with the transition to high school, efforts to intervene to affect these changes will be somewhat speculative.

Taken together, changes in students' math competence beliefs across the transition to high school were the major contributing factor in predicting changes in students' valuing of math during this same period. In addition, the direct and indirect effects of changes in math competence beliefs across the transition to high school on students' Grade 9 math performance and on girls' math enrolment intentions renders it a key variable in terms of where to invest prevention and intervention efforts. Having identified a target area on which to focus attention (students' math competence beliefs), the question remains of what to do to lessen the adverse affects of the transition to high school period in this respect. Based on the results of the present study, we do not have a solid answer to this question. We can only infer action based on results of past studies that have not incorporated change scores into their models. This emphasizes the need to further investigate factors that are predictive of the changes students experience in their math competence beliefs and math values across the transition to high school.

The Significance of Post-Transition Change

In Model 2, we were interested in the effects of the changes students experience in their math competence beliefs and values for math in the year after the transition to high school. As such, we examined the predictive role of changes in math competence beliefs and utility and intrinsic values for math (from Grades 9 to 10) on students' Grade 10 math performance and math enrolment intentions. This post-transition time is an important period within which to look at the effects of change for several reasons. First, it represents the period of adaptation from the transition to high school year. Second, it marks the beginnings of course selection. Specifically, in Grade 10, students make decisions regarding the level of math they wish to pursue (e.g., standard vs. advanced courses).

Lastly, it is the period that immediately precedes students' legal age for dropping out of school (age 16 in Canada). These points highlight the significance of examining the effects of these changes on students' Grade 10 math performance and math enrolment intentions. When it comes to performance, the math grades students obtain early in high school will undoubtedly influence their acceptance into upper-level math courses later in high school. In terms of math enrolment intentions, decisions students make regarding their involvement in the math stream beginning in Grade 10 will either broaden or limit their future educational and occupational options.

Post Transition Change in the Present Study

Before discussing the effects of the changes in students' math-related competence beliefs and values in the year following the transition year to high school, we will summarize results from Part 1 regarding the kinds of changes students are experiencing in these areas across Grades 8, 9, and 10. Our results concerning the mean-level changes in students' math competence beliefs and values for math indicate a general negative trend across the three years. However, looking specifically at changes from Grades 9 to 10, it appears as though students (on average) follow one of three general patterns. Keeping in mind that these results are based on mean-level changes and do not reflect individual differences, the three general patterns are as follows. (1) Some students continue to show declines in their math-related competence beliefs and values. The magnitude of declines in some variables from Grades 9 to 10 is not significantly greater or less than the declines students experienced over the transition year (Grades 8 to 9) (e.g., math competence beliefs). (2) The decline that some students experience from Grades 9 to 10 is significantly greater in magnitude than what they had experienced from Grades 8 to 9 (e.g., students'

utility value). (3) Some students experienced no decline from Grades 8 through 10 (e.g., girls' intrinsic valuing of math). These results are important in revealing that many students continue to experience change in their math-related competence beliefs and values in the year after the transition to high school and that there exists some variability in these changes. Thus, having established that changes in math competence beliefs and values for math persist into the year after the transition to high school, our goal was to determine if and how these changes relate to students' subsequent math performance and math enrolment intentions (in Grade 10).

*Model 2: Support for the Hypothesized Key Relations between Variables Outlined in
Eccles' Model*

The focus of this section of the discussion is on support for the longer-term effects of students' pre-transition Grade 8 math grades, math competence beliefs, and values for math on their math performance and math enrolment intentions two years into high school (Grade 10). A discussion of the results involving the change scores in Model 2 follows this section.

Results for boys in Model 2 indicate that their pre-transition math grades and math competence beliefs were significant in predicting directly their Grade 10 math performance. Their Grade 8 math competence beliefs also had an indirect effect on their Grade 10 math grades, through their Grade 8 math grades. Consistent with the results of Model 1, boys' Grade 8 math grades predicted directly their math enrolment intentions in Grade 10. For girls, the only significant influence of their Grade 8 variables on their Grade 10 outcome variables was the direct and indirect effects of their Grade 8 math grades on

their Grade 10 math grades and the indirect effect of their Grade 8 math grades on their Grade 10 math enrolment intentions.

As mentioned for the results of Model 1, the cyclical relation between math grades and math competence beliefs is well founded in the literature (Casey et al, 1997; Crombie et al., 2005; Frome & Eccles, 1998; Valentine et al., 2004). The feedback (e.g., grades) students receive about their math performance informs and influences their perceptions of their math ability, with more positive feedback being associated with higher math competence beliefs (e.g., Parsons [Eccles] et al., 1984; Simpkins et al., 2006). The confidence that students feel when they believe they are good in math, in turn, positively influences their achievement in subsequent math courses.

With the exception of paths from math grades and of the path from math competence beliefs for boys, no other Grade 8 variable had longer-term direct effects on students' math performance and math enrolment intentions in Grade 10. Specifically, neither boys nor girls' values for math in Grade 8 were predictive of their Grade 10 math enrolment intentions as we predicted might occur. Also not consistent with our results in Model 1, girls' math competence beliefs in Grade 8 had no direct or indirect effects on their math performance or math enrolment intentions in Grade 10. It is interesting that, beyond the immediate effect on their Grade 9 outcome variables, the influence of competence beliefs for girls occurs through the changes they experience in this variable across and after the transition to high school. For boys, however, Grade 8 math competence beliefs continue to have an effect on their math performance into their Grade 10 year. The significance of the changes both boys and girls experience in their math competence beliefs from Grades 9 to 10 is discussed below.

Model 2: The Influence of Changes in Math Competence Beliefs After the Transition to High School

Our results suggest that the changes students experience in their math competence beliefs in year after the transition to high school (Grades 9 to 10) have important effects on their math performance and on girls' math enrolment intentions two years into high school (Grade 10). Moreover, the pattern of relations between the change variables and the outcome variables in Model 2 is largely consistent with those same relations in Model 1. In other words, the effects of changes in students' math-related competence beliefs from Grades 9 to 10 on their math performance and on girls' math enrolment intentions in Grade 10 is similar to the relation between these same variables over the transition to high school (Grades 8 to 9).

Our results support the predictive relation from math competence beliefs to math performance. Specifically, for both boys and girls, changes in math competence beliefs from Grades 9 to 10 directly predicted their Grade 10 math grades. The magnitude of this predictive relation was somewhat stronger in Model 2 than it was in Model 1, when students made the transition to high school (from Grades 8 to 9). As mentioned earlier, the lack of research examining the effects of changes in this area across and after the transition to high school makes comparing our results with those of others not possible. However, our results pertaining exclusively to the pattern of relations between math competence beliefs and math performance have been supported by studies that have incorporated measurements of these same variables, without looking at change specifically. For example, that students' math competence beliefs have a direct effect in predicting their subsequent math grades is a finding that has been reported by many researchers, and not

just in the area of mathematics (e.g., Frome & Eccles, 1998; Valentine et al., 2004). Given the lack of research incorporating change scores in this area, our Model 2 results become that much more important in providing corroborating evidence for our Model 1 results. In other words, because Models 1 and 2 both included change scores of the same variables on the same students, their results can be compared in a meaningful way. The consistency between Model 1's and Model 2's results, albeit covering different time periods, increases the reliability of our findings.

One finding that was present in Model 1, but only significant at $p < .05$ in Model 2, was the path from changes in math competence beliefs to girls' math enrolment intentions. Albeit only significant at $p < .05$, this path is important in that it provides support for the continuity of the predictive relation between changes in girls' math competence beliefs and their subsequent math enrolment intentions. Although the strength of the association in Model 2 was less than it was in Model 1, we are seeing that the changes girls experience in their math competence beliefs from Grades 9 to 10 continue to influence their Grade 10 math enrolment intentions. Across both models, the changes girls experienced in their math competence beliefs (from Grades 8 to 9 and from Grades 9 to 10) had significant and larger effects on both their Grade 9 and Grade 10 math enrolment intentions, respectively, than did their pre-transition Grade 8 levels of math competence beliefs. This association is particularly relevant when it comes to maintaining girls' involvement in math and in narrowing the gender gap in math-related careers. Specifically, if we can reduce the negative effects of the transition to high school on girls' math competence beliefs and use the subsequent years to help build their ability perceptions, girls' math involvement will likely increase. As mentioned earlier, because Grade 10 marks the beginning of course

selection, girls' math enrolment intentions become increasingly salient at this point in their lives.

Model 2: The Influence of Changes in Values for Math After the Transition to High School

With respect to the predictive relation between values for math to math enrolment intentions, our results for boys differ from Model 1 to Model 2. In Model 1, boys' Grade 9 math enrolment intentions were directly predicted by the changes they experienced in their utility value for math across the transition to high school (Grades 8 to 9). In Model 2, however, it was the changes boys experienced in their intrinsic value for math from Grades 9 to 10 that were significant in predicting their Grade 10 math enrolment intentions. Although there appears to be a shift in the significance of the influence of changes in boys' utility value for math to changes in their intrinsic valuing of math across the two models, the path from changes in boys' utility value for math (from Grades 8 to 9) to their Grade 9 math enrolment intentions was greater in magnitude than was the path from changes in their intrinsic value for math (from Grades 9 to 10) to their Grade 10 math enrolment intentions.

By way of explanation, boys' interest in math at this point may become increasingly salient in predicting their subsequent math enrolment intentions because of the greater diversity of math courses offered to them in the upper high school years. Specifically, once students reach a certain point in high school, decisions about math enrolment are not restricted to standard versus enriched. Rather, because a variety of different math courses are made available to them (e.g., algebra, calculus, finite, etc.), their interests in math may become refined, increasing for some of these courses and decreasing for others. As such, the changes in boys' intrinsic valuing of math may play a greater role in predicting their

math enrolment in this regard. It is important to note that the absence of a significant path from changes in boys' utility value for math from Grades 9 to 10 to their Grade 10 math enrolment intentions does not infer that boys' utility value for math was unimportant in predicting their math enrolment intentions. Rather, it means that the **changes** they experienced in their perceived usefulness of math from Grades 9 to 10 were not significant in influencing their Grade 10 math enrolment intentions.

Despite a shift in the influence of boys' values for math, changes in utility value for math from Grades 9 to 10 continue to influence girls' Grade 10 math enrolment intentions when they do not for boys. It could be that girls' perceptions of the usefulness of math become increasingly salient once they foresee needing to make choices about their math enrolment, whereas boys' recognition of the usefulness of math presents earlier and/or does not increase when course selection becomes an option. If this were the case, changes in utility value for math from Grades 9 to 10 (negative changes in our sample) may be having a stronger effect on the Grade 10 math enrolment intentions of girls than of boys.

Our results suggest that the changes girls' experience in their intrinsic value for math from Grades 9 to 10 were not predictive of their Grade 10 math enrolment intentions. This may reflect in part the fact that we found no mean-level changes in girls' intrinsic value for math from Grades 9 to 10. As such, it may be that changes in girls' intrinsic math value are significantly predictive of their math enrolment intentions, but that the magnitude of the changes they experienced in their intrinsic value for math from Grades 9 to 10 was not significant in affecting their Grade 10 math enrolment intentions. The fact that girls' pre-transition Grade 8 intrinsic value for math predicted directly their Grade 9 math enrolment intentions in Model 1 lends some support for the short-term predictive relation

between these two variables. However, there were no significant direct paths from girls' Grade 8 math intrinsic value or from changes in their intrinsic math values (Grades 9 to 10) to their Grade 10 math enrolment intentions. As such, an alternative possibility is that the strength of the influence of this variable girls' math intrinsic value may be less pronounced at this point than it was in earlier years. Taken together, further research is needed to assess more fully the influence of changes in girls' intrinsic value for math on their math enrolment intentions.

Model 2: Direction of Causality between Math Competence Beliefs and Values for Math

In Model 2, Grade 8 math competence beliefs were not significant in predicting changes in either boys or girls' values for math from Grades 9 to 10. With the exception of a significant path from girls' Grade 8 intrinsic value for math to changes in their math competence beliefs from Grades 9 to 10, we found no support for a direction of causality from values to competence beliefs either. Based on the results on Model 2 therefore, there is no support for either direction of causality between math competence beliefs and values for math. With an absence of significant paths in both directions for boys and girls (with the exception of the one path mentioned above for girls), we do not have support for the direction of causality between these two variables.

In both Models 1 and 2, the changes that students experienced in their math competence beliefs from one year to the next were directly predictive of the changes they experienced in their utility and intrinsic values for math across the same time period. Because we did not test the paths from changes in students' utility and intrinsic values for math to changes in their math competence beliefs, we cannot conclude exclusively that the direction of causality runs from changes in students' math competence beliefs to changes in

their values for math. However, we do know that, irrespective of drawing conclusions about a direction of causality, changes in students' math competence beliefs consistently and strongly predicted changes in their utility and intrinsic values for math. As such, in combination with their effects on students' math performance and on girls' math enrolment intentions (in both models), changes in math competence beliefs are presenting as a key variable in students' adaptation across and after the transition to high school.

Predicting Changes from Grades 9 to 10

Among the four Grade 8 variables included in the present study, students' pre-transition Grade 8 math grades had the most consistent effects on the changes they experienced in their math competence beliefs from Grades 9 to 10. In fact, albeit small in effect size, Grade 8 math grades directly predicted changes in students' math competence beliefs from Grades 8 to 9 (across the transition to high school) and from Grades 9 to 10 (in the year after the transition). Although the path from Grade 8 math grades to changes in students' math competence beliefs from Grades 9 to 10 was small in magnitude, what is notable is that the predictive effects of Grade 8 math grades were consistent across gender and time. Furthermore, pre-transition math grades were the only Grade 8 variable in the present study that had consistent direct effects on any of the change variables included in the two models. These results are important in our understanding of the influence of students' pre-transition math achievement.

By way of extending previous research, we have refined our current understanding of the reciprocal association between math achievement and math competence beliefs. Specifically, we now know that the association between students' math grades and their math competence beliefs extends to include changes in their math competence beliefs

across and after the transition to high school. This is particularly significant because the changes students experienced in their math competence beliefs across these three years were directly predictive of their subsequent math performance and math enrolment intentions.

Other than the direct paths from students' pre-transition Grade 8 math grades to changes in the math competence beliefs from Grades 9 to 10, there was only one other Grade 8 variable that had direct effects on the change scores from Grades 9 to 10. In Model 2, Grade 8 intrinsic value for math was significant in predicting change variables (from Grades 9 to 10) for both boys and girls. It is interesting that this Grade 8 variable did not significantly predict any changes for either boys or girls across the transition to high school (from Grades 8 to 9), yet predicted changes in boys' utility value for math and changes in girls' math competence beliefs from Grades 9 to 10. Timing may help explain the relevance of students' pre-transition intrinsic value for math to changes in their math-related beliefs and values in the post-transition period. As mentioned earlier, because at the end of Grade 10 students begin making choices about their math involvement (e.g., type of math course, as well as level of difficulty), their intrinsic values for math may have more of an influence at this time than they did from Grades 8 to 9. With girls holding a more mastery orientation to their math work, it is possible that the direct effect of their Grade 8 math intrinsic value on changes in their math competence beliefs from Grades 9 to 10 is due to the effort they are willing to expend in their math courses. Specifically, given that intrinsic motivation is central to a mastery approach to school work, it is possible that girls who have a high intrinsic value for math will expend more time, energy, and effort toward doing well. Girls' intrinsic value for interest and hard work in math may provide them with

a greater sense of ability, and may therefore affect the changes they experience in their math competence beliefs. It may be that increasing girls' intrinsic value for math before making the transition to high school would help reduce the magnitude of the decline they experience in their math-related competence beliefs and values after the transition to high school.

Summary and Conclusion of Model 2

The timeframe of Model 2, as well as the particular variables included in the model, were significant in allowing us to both support and extend previous research pertaining to the important transition to high school and the post-transition period. By including data from Grades 8, 9, and 10, our results were helpful in refining the existing relations between students' math performance, math competence beliefs, values for math, and math enrolment intentions across and after the transition to high school. In Model 2, we extended previous research by (1) examining the influence of Grade 8 variables on changes in students' math competence beliefs and values for math after the transition to high school and on their math performance and math enrolment intentions in Grade 10 and (2) assessing directly the influence of the changes students' experience in their math competence beliefs and values for math in the year after the transition to high school. In terms of assessing the influence of change, we have evidence to suggest that it is the changes students' experience in their math competence beliefs and values for math from Grades 9 to 10, and not their pre-transition levels of these same variables, that directly predict their Grade 10 math performance and math enrolment intentions

The consistent role of students' pre-transition Grade 8 math grades in predicting longer-term changes in their math competence beliefs (from Grades 9 to 10), as well as

their math performance and boys' math enrolment intentions in Grade 10 is significant in identifying this as an area of potential intervention. Specifically, given their direct and indirect and short and longer-term effects on the change and outcome variables in the present study, it would appear that efforts to increase students' pre-transition Grade 8 math grades would be successful in partly attenuating the negative effects associated with the transition to high school.

It is important to note, however, that the effects of students' Grade 8 math grades on the changes they experienced in their math competence beliefs were small in magnitude. As such, we continue to have little information about the factors that actually influence the changes that students are experiencing in their math competence beliefs across and after the transition to high school. Given the predictive effects of changes in math competence beliefs and values for math on students' subsequent math performance and math enrolment intentions, more research is needed to enable a broader investigation of the changes students experience in their math competence beliefs across and after the transition to high school.

Applied Implications

From an applied perspective, several implications can be derived from the present study. The analysis of our results regarding students' math-related beliefs and values, changes in these beliefs and values, and their impact on students' math achievement and math enrolment intentions leads to important conclusions. The changes students' experienced in their math competence beliefs and values for math across Grades 8 and 9, and again across Grades 9 and 10, were predictive of their math achievement and math enrolment intentions in Grades 9 and 10, respectively. Students' pre-transition Grade 8

math competence beliefs and values for math were also significantly predictive of these same outcomes in Grade 9, but not in Grade 10. Furthermore, changes in math competence beliefs and values for math across the transition to high school (from Grades 8 to 9) were equal if not stronger predictors of students' Grade 9 math achievement and math enrolment intentions. From Grades 9 to 10, changes in math competence beliefs and values were directly predictive of students' Grade 10 math achievement and math enrolment intentions, whereas their pre-transition levels of these same constructs were not. Together, these results indicate that it is the negative changes that students experience in their math competence beliefs and values for math across and after the transition to high school that are associated with more risk, rather than their pre-transition Grade 8 math competence beliefs and values.

These findings are important because they suggest that efforts to reduce the negative effects associated with the transition to high school by increasing students' pre-transition ability beliefs and values for math will be limited in their effect. As such, it is important that educators (teachers and parents) be aware of those students who show significant drops in their ability beliefs and values for math across and after the transition to high school, in addition to those students who maintained their existing low levels of math competence beliefs and values for math from elementary school. Interventions should occur not only before students move into high school but also throughout and after the transition period itself.

By way of early interventions, previous research has pointed to the significance of increasing students' positive experiences with math and out-of-school involvement in math-related activities (Dickhauser & Stiensmeier-Pelster, 2002; Simpkins et al., 2006) and

increasing parental involvement and expectations when it comes to their child's math courses (Herbert & Stipek, 2005) as some methods to increase students' math ability perceptions. In terms of later efforts, the focus of interventions should be on reducing the negative changes students are experiencing in their math competence beliefs and values for math and working toward helping them gain confidence in their math ability. Results of our model indicate that the changes students experience in their math competence beliefs across and after the transition to high school are directly predictive of the changes they experience in their values for math. With this in mind, efforts directed at helping students work toward more positive math competence beliefs will, by association, have a similar effect on their math values.

One way to help reduce the drop in students' math competence beliefs across the transition to high school would be for Grade 9 math teachers to offer a lengthier review period of math material taught in elementary school and limit the introduction of new material until students have had the chance to adjust somewhat to the high school environment. If this were the case, it is likely that students would initially feel more familiar with the material and more confident in their ability to succeed in this respect. Awareness and early identification of students who have low math competence beliefs and of students who are showing declines in these beliefs in the first year or two of high school are also important. Additional support for these students, perhaps in the form of increased teacher and peer support or tutoring, may also prove beneficial in helping them increase their perceptions of their own math ability.

Generally speaking, changes in students' values for math across and after the transition to high school were predictive of their Grades 9 and 10 math enrolment

intentions. Specifically, the changes that students experienced in their perceptions of the usefulness of math as they moved into high school were predictive of their Grade 9 math enrolment intentions. Changes in this same variable, this time from Grade 9 to 10, were predictive of girls' Grade 10 math enrolment intentions. Given this association, combined with the predictive effect of students' pre-transition Grade 8 values for math on their Grade 9 math enrolment intentions, the extent to which students internalize the usefulness of math will bear important consequences for their continued involvement in the math stream. As such, active efforts by parents and educators to communicate to students the necessity of math for future educational and occupational careers become central. Education about the relevance of math and the practical implications of choosing to remain in the math stream (or not) will help students foresee the importance of their continued enrolment in math. Once again, combining our results regarding the effects of students pre-transition utility value for math with the effects of the changes they experience in their perceptions of the usefulness of math, it appears that the aforementioned role of education needs to be consistent and include the period during and after which students make the transition to high school.

Although students' Grade 8 math grades were predictive of their math achievement in Grade 9 and 10 and had a small influence on the changes they experienced in their math competence beliefs across and after the transition to high school, efforts that focus solely on increasing students' objective math performance will be limited in their effect. Additional efforts are needed to target and head off the declines that students are experiencing in their math competence beliefs and values across and after the transition to

high school. A second step would be to work toward helping students develop more positive math competence beliefs and values for math as they progress through high school.

Finally, the age-old adage of “knowledge is power” cannot be underestimated when working with youth. Adolescents are fully capable of understanding, conceptualizing, and internalizing information presented to them. Increasing their awareness of what have been the typical negative effects associated with making the transition to school will empower them to be active participants in breaking the cycle. Educating students about the significant effects of their math-related beliefs and values and about the effects of changes in these variables on their future math performance and math enrolment intentions will enable them to help themselves as well. Major developmental goals in adolescence include identity and autonomy. With this in mind, it is likely that students will welcome efforts that help them become more active agents in decisions about their educational paths at this point in their lives.

Strengths and Limitations of the Study

The present study was designed to support and extend the existing literature in several respects. Among our most significant contribution to the extant research was the examination of the effects of changes in students’ math competence beliefs and values for math across and after the transition to high school. Although conclusions have been drawn by researchers about the negative effects of the transition to high school period and their associations with poor outcomes, our study is the first that we know of that has examined the influence of the changes themselves (in math-related competence beliefs and values) on students’ math achievement and math enrolment intentions over this time period.

A second noteworthy strength of the present study was that, due to our reasonably large sample size, we were able to examine each of the models separately for boys and girls. This was particularly important in ensuring the identification of any relations between the variables that may differ by gender. For example, it is likely that the direct path from changes in math competence beliefs to math enrolment intentions would not have been significant had we tested the models on the combined sample. Researchers have suggested that when it comes to math and science, in particular, men and women differ in the processes involved in career choice (Farmer, Wardrop, & Rotella, 1999; Trusty, 2002).

A third strength involved the longitudinal nature of the present study. Specifically, in addition to looking at changes in math competence beliefs and values for math that occur across the transition to high school (from Grades 8 to 9), we were also able to examine the effects of the changes in these same variables in the year after (from Grade 9 to 10). Furthermore, we incorporated students' pre-transition Grade 8 measures in order to examine the differential effects of their existing levels of math competence beliefs and values and of the changes they experience in the variables across and after the transition to high school. Including Grade 8 variables also enabled us to examine any longer term effects they may have on the changes students experience in their math competence beliefs and values for math at this time, as well as on their math achievement and math enrolment intentions.

Although the present study provided support for and extended previous research in the area, there were also some limitations. Each of these will be addressed as they pertain to specific areas of the study.

Conceptual Issues

The present study was based on key constructs from Eccles and colleagues' expectancy-value model of achievement. However, our inclusion of variables was limited to achievement-related variables and did not incorporate other important factors specific to the model (e.g., social variables). Whereas we were able to address the research questions we had originally proposed (e.g., the effects of the changes of math competence beliefs and values for math on students' math achievement and math enrolment intentions), including a more broad range of explanatory factors may have enabled us to answer other important research questions. Specifically, with the inclusion of other variables in the model, it is possible that we would have been able to identify some factors that directly predict the changes that students experience in their math competence beliefs and values for math across and after the transition to high school.

A second limitation involves the timing and context of the transition to high school period itself. Specifically, the changes that we ascribe to the transition to high school period took place from Grades 8 to 9. However, we know that some students' make transitions earlier, moving from elementary school to a combined middle and high school setting (e.g., Grade 7 onward). Also, some students make the transition to high school without actually changing schools. Still others make more than one transition, moving from elementary to middle to high school in three separate transitions. Due to the variability of the timing and frequency of school transitions, our results may only be generalizable to students who make the transition to high school from Grade 8 to 9.

Measurement Issues

Perhaps the most significant measurement confound centered on students' math enrolment intentions. First, our measure for math enrolment intentions included only one item. Although this measure has been used in previous research and has demonstrated good test-retest reliability, it remains questionable whether one item can accurately capture students' decisions about the future of their math involvement. Second, we assessed students' enrolment intentions rather than their actual enrolment. Although there is research to suggest that dropout intentions reliably predict actual dropout (Vallerand, Fortier, & Guay, 1997), it would have been useful to have had measures of both.

Statistical limitations

The lack of multiple indicators at the measurement level limited our use of statistical analyses. Specifically, if we had more items in the measurement of certain variables in our models (e.g., intrinsic value for math, math enrolment intentions, and math achievement), more powerful analyses could have been employed. With multiple indicators, we would have likely used the true intra-individual change (TIC) technique of structural equation modeling, an analysis in which the measurement of true intra-individual change between two time periods is examined at the latent variable level.

Directions for Future Research

Although our three years of data incorporated the year immediately preceding and proceeding the actual transition to high school, including an additional year on either end would have added to the strength of the study. Specifically, had we broadened the scope of the present research to include Grades 7 to 11 inclusively, our results would have been more informative in several important ways. First, by extending the study on the front end

(e.g., pre-transition time), we would have been able to examine whether the magnitude of the negative changes that are occurring at the transition period are significantly different from those occurring earlier. This comparison is important given that some researchers have documented negative changes in students' math competence beliefs and values for math beginning in late elementary school and early middle school. With Grade 7 data, we would have been able to compare the effects of the negative changes that are occurring across the transition to high school with the effects of the changes in similar variables between Grades 7 and 8.

Extending the present study to include Grade 11 data would have allowed us to see the further development of certain trends observed in the present study. For example, with respect to mean-level changes and stability measures, our results indicated that boys' utility value for math began to stabilize following the drop during the transitional year (Grades 8 to 9). Other researchers have documented a similar trend for students' perceptions of the importance of math (Fredricks & Eccles, 2002) and for students' intrinsic motivation for math (Gottfried et al., 2001). With the intention of extending the present study, it will be interesting to see if these same trends develop with our sample. Finally, given that we have three additional years of data on the students included in the present sample, the following questions are ones we hope to answer in subsequent research: Do changes across the transition to high school predict changes in other years? Do the negative changes in math competence beliefs and values for math across the transition to high school predict students' math achievement and enrolment intentions in later high school years? The answers to these questions are important in obtaining an accurate view of the effects of the transition to high school. Although there were numerous avenues we could have pursued in

the present research project, we chose to limit our study to Grades 8, 9, and 10 in order to single out the effects of the negative changes in students' math competence beliefs and values for math across transition period itself. With this as a preliminary basis, we now have a more solid ground on which to pursue subsequent research.

Another direction for future research that is worthy of investigation is the examination of the effects of changes in other variables across the transition to high school. For example, studies have shown that students' perceptions of the support they receive from parents, teachers, and friends, all play an important role in how they experience and adapt from the transition to high school. Given our results regarding the significant predictive effects of the changes in math competence beliefs and values themselves, it is plausible that the changes in these other variables across the transition to high school may also be implicated in students' post-transition adjustment and outcome.

Conclusion

Conclusions about the negative effects of the transition to high school period cannot be drawn with certainty without looking at the predictive role of the changes themselves that students are experiencing at this time. Our understanding of the predictive effects of the changes students are experiencing across and after the transition will be equally limited without first examining at the nature (e.g., magnitude and direction) of the changes that are occurring at this time. The present study was successful in investigating both.

In Part 1, we looked at the nature of the changes students experienced in their math competence beliefs, values for math, math achievement, and math enrolment intentions across and after the transition to high school period. By examining mean-level changes as a measure of group stability and stability correlations as a measure of the cross-time stability

of an individual's position within a group, we were able to provide an accurate image of the developmental trajectory of each variable as students move from Grade 8 through to Grade 10.

Our results in Part 2 extended previous research and indicated that the actual changes students experience in their math competence beliefs and values for math across the transition to high school are directly predictive of their Grade 9 math performance and math enrolment intentions. Furthermore, in terms of magnitude, their role in predicting Grade 9 math performance and math enrolment intentions was equal to, and generally greater than, the predictive effects of students' pre-transition Grade 8 math competence beliefs and values. These findings highlight the need to examine more fully the effects of the actual measured changes students are experiencing in their ability beliefs and values for math as they move into high school.

In Part 3, we looked at the post-transition period as an important timeframe within which to further examine the effects of changes in students' math competence beliefs and values for math. Grade 10 represents the most immediate period of adaptation after the transition to high school itself and marks the beginnings of course selection for many students. Paralleling our results from Part 2, in general, changes in math competence beliefs predicted math performance and changes in values for math predicted math enrolment intentions. However, students' pre-transition math competence belief and values for math had little to no longer-term effects on their Grade 10 math performance and math enrolment intentions.

The trend we observe from the present study is that the changes students experience in their math competence beliefs and values for math across and after the transition to high

school are significant and consistent predictors of their subsequent math performance and math enrolment intentions. Conclusions about the negative effects of the transition to high school, based solely on the effects of students' pre-transition math competence beliefs and values, provide a limited understanding. Even with the established predictive relations between pre-transition math-related ability beliefs and values and post-transition math achievement and enrolment intentions, failing to look at the influence of the changes students are experiencing in these variables themselves limits our understanding of the effects of the transition to high school. Finally, from an applied perspective, the results of the present study point to the need for efforts and interventions directed at reducing the negative effects associated with the transition to high school to be continuous and inclusive of both the pre-transition and post-transition periods.

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Appendix C
Items from the Adolescent Questionnaire

**Adolescent Math Constructs
(Pages 8-9 of Questionnaire)**

Math Competence Beliefs

1. How good at math are you? (1) not at all good, (7) very good.
2. If you were to rank all the students in your math class from the worst to the best in math, where would you put yourself? (1) the worst, (7) the best.
3. Compared to most of your other school subjects, how good are you at math? (1) much worse, (7) much better.
4. How well do you think you will do in math this year? (1) not at all well, (7) very Well.

Utility Value for Math

1. In general, how useful is what you learn in math? (1) not at all useful, (7) very useful
2. How useful do you think the math you are learning will be for what you want to do after you graduate and go to work? (1) not at all useful, (7) very useful
3. Is the amount of effort it will take you to do well in math this year worthwhile to you? (1) not at all worthwhile, (7) very worthwhile
4. How useful do you think high school math will be for what you want to do after you graduate and go to work? (1) not at all useful, (7) very useful

Intrinsic Value for Math

1. How much do you like doing math? (1) a little, (7) a lot
2. In general, I find working on math assignments... (1) very boring, (7) very interesting

Math Enrolment Intentions

1. Will you take more math when you don't have to? (1) I very definitely will take more math, (7) I very definitely will not take any more math

Appendix D

Model 2: Intercorrelations Between Grades 8 to 10 Variables as a Function of Gender

Model 2: Intercorrelations Between Grades 8 to 10 Variables as a Function of Gender										
Measure	1	2	3	4	5	6	7	8	9	10
1. Grades (T1)	--	.55**	.64**	.42**	.11	.22**	.25**	.32**	.26**	.33**
2. Grades (T3)	.50**	--	.43**	.79**	.08	.48**	.12*	.56**	.20**	.46**
3. Comp beliefs(T1)	.66**	.37**	--	.41**	.29**	.33**	.51**	.38**	.35**	.31**
4. Comp beliefs (T3)	.41**	.74**	.43**	--	.09	.53**	.18**	.67**	.15*	.41**
5. Ut value (T1)	.26**	.17**	.45**	.16**	--	.43**	.57**	.26**	.41*	.16*
6. Ut value (T3)	.23**	.39**	.27**	.45**	.43**	--	.42**	.65**	.27**	.45**
7. Int value (T1)	.41**	.22**	.65**	.33**	.55**	.35**	--	.45**	.36**	.19**
8. Int value (T3)	.33**	.52**	.38**	.67**	.23**	.61**	.48**	--	.28**	.46**
9. Enr intentions (T1)	.29**	.20**	.41**	.16**	.47**	.29**	.45**	.23**	--	.37**
10. Enr intentions (T3)	.19**	.43**	.23**	.43**	.24**	.46**	.26**	.47**	.32**	--

Note. Intercorrelations for male and female participants are presented above and below the diagonal, respectively. For T1 correlations, $n = 290$ for boys and $n = 311$ for girls; For T3 correlations, $n = 249$ for boys and $n = 255$ for girls. T1 = Time 1 (Grade 8); T3 = Time 3 (Grade 10); Comp beliefs = math competence beliefs. Ut value = math utility value. Int value = math intrinsic value. Enr intentions = math enrolment intentions.

* $p < .05$. ** $p < .01$.

Appendix E
2 x 3 Analysis of Variance for Math Grades

2 x 3 Analysis of Variance for Math Grades

Source	df	MS	F
Within Subjects			
Grades	2	6144.83	73.47**
Grades X Gender	2	191.30	2.29
Error	502	96.41	
Between Subjects			
Gender	1	2612.03	6.01**
Error	502	434.75	

Note. $\underline{n}$ = 255 females; $\underline{n}$ = 249 males

** $p < .05$. ** $p < .01$.

Appendix F
2 x 3 Analysis of Variance for Math Competence Beliefs

2 x 3 Analysis of Variance for Math Competence Beliefs

Source	df	MS	F
Within Subjects			
Competence beliefs	2	19.87	22.79**
Comp beliefs X Gender	2	2.13	2.44
Error	502	1.06	
Between Subjects			
Gender	1	48.21	13.69**
Error	502	3.52	

Note. $\underline{n}$ = 255 females; $\underline{n}$ = 249 males

** $p < .05$. ** $p < .01$.

Appendix G
2 x 3 Analysis of Variance for Math Utility Value

2 x 3 Analysis of Variance for Math Utility Value

Source	df	MS	F
Within Subjects			
Utility value	2	27.10	32.14**
Utility value X Gender	2	1.65	1.96
Error	502	1.04	
Between Subjects			
Gender	1	0.03	0.01
Error	502	3.62	

Note. $\underline{n}$ = 255 females; $\underline{n}$ = 249 males

** $p < .05$. ** $p < .01$.

Appendix H
2 x 3 Analysis of Variance for Math Intrinsic Value

2 x 3 Analysis of Variance for Math Intrinsic Value

Source	df	MS	F
Within Subjects			
Intrinsic value	2	15.09	12.25**
Intrinsic value X Gender	2	5.68	4.61*
Error	502	1.48	
Between Subjects			
Gender	1	0.15	0.03
Error	502	5.63	

Note. $\underline{n}$ = 255 females; $\underline{n}$ = 249 males

** $p < .05$. * $p < .01$.

Appendix I
2 x 3 Analysis of Variance for Math Enrolment Intentions

2 x 3 Analysis of Variance for Math Enrolment Intentions

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Within Subjects			
Enrolment Intentions	2	278.07	146.84**
Enr Intentions X Gender	2	2.51	1.33
Error	502	1.48	
Between Subjects			
Gender	1	0.15	0.03
Error	502	5.63	

Note. $\underline{n}$ = 255 females; $\underline{n}$ = 249 males

** $p < .05$. ** $p < .01$.