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Gendered Motivational Processes Affecting High School Mathematics Participation, Educational Aspirations, and Career Plans: A Comparison of Samples From Australia, Canada, and the United States

Helen M. G. Watt
Monash University

Jennifer D. Shapka
University of British Columbia

Zoe A. Morris
Monash University

Amanda M. Durik
Northern Illinois University

Daniel P. Keating and Jacquelynne S. Eccles
University of Michigan

In this international, longitudinal study, we explored gender differences in, and gendered relationships among, math-related motivations emphasized in the Eccles (Parsons) et al. (1983) expectancy-value framework, high school math participation, educational aspirations, and career plans. Participants were from Australia, Canada, and the United States (*N*s = 358, 471, 418, respectively) in Grades 9/10 at Time 1 and Grades 11/12 at Time 2. The 3 samples came from suburban middle to upper-middle socioeconomic backgrounds, primarily of Anglo-European descent. Multivariate analyses of variance revealed stereotypic gender differences in educational and occupational outcomes only among the Australian sample. Multigroup structural equation models identified latent mean differences where male adolescents held higher intrinsic value for math in the Australian sample and higher ability/success expectancy in both North American samples. Ability/success expectancy was a key predictor in the North American samples, in contrast to intrinsic value in the Australian sample. Attainment/utility ("importance") values were more important for female adolescents' career choices, except in the Australian sample. Findings are interpreted in relation to gender socialization practices, degree and type of early choice, and specialization across settings. Implications are discussed for long-term math engagement and career selection for female and male adolescents.

Keywords: motivations, mathematics, gender, longitudinal, international comparison

Over the past two decades, there has been an alarming decline in advanced science and mathematics participation in many Western countries (e.g., National Science Board, 2003; National Science Foundation, 2002; National Strategic Review of Mathematical Sciences Research in Australia, 2006; Natural Sciences and Engineering Research Council of Canada, 2010) and a paucity of qualified individuals entering the so-called STEM careers (science, technology, engineering, and mathematics). Why? Although there are some countries where women outperform men and participate noticeably in STEM fields (from PISA 2009: Science—Finland,

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Helen M. G. Watt, Faculty of Education, Monash University, Melbourne, Victoria, Australia; Jennifer D. Shapka, Education and Counselling Psychology and Special Education, University of British Columbia, Vancouver, British Columbia, Canada; Zoe A. Morris, Faculty of Education, Monash University; Amanda M. Durik, Department of Psychology, Northern Illinois University; Daniel P. Keating and Jacquelynne S. Eccles, Department of Psychology, University of Michigan.

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Correspondence concerning this article should be addressed to Helen M. G. Watt, Faculty of Education, Monash University (Clayton Campus), Wellington Road, Melbourne, Victoria 3800, Australia. E-mail: helen.watt@monash.edu

Slovenia, Turkey, Greece, Poland, Jordan, Albania, Dubai UAE, Qatar, Kyrgyzstan, Bulgaria, Trinidad and Tobago, Lithuania, Thailand, Montenegro, Romania, Indonesia, Kazakhstan, Argentina, Azerbaijan, and Latvia; Mathematics—Qatar, Kyrgyzstan, Lithuania, Albania, and Trinidad and Tobago; OECD, 2010), on average, women in Organization for Economic Cooperation and Development (OECD) countries attain 30% of STEM degrees; in some countries the rate is as low as 9% (OECD, 2004). Thus, of the dwindling numbers of "native" students in Australia, Canada, and the United States entering STEM majors and occupations, proportionally fewer of them are women. Again why?

Efforts to understand these questions have led people to think about the pathways into STEM in terms of a leaky pipeline, with people dropping out at various points along their educational and occupational careers. The leaky STEM pipeline has become a major area of concern in terms of economic growth across many Western countries (see Jacobs, 2005; Jacobs & Simpkins, 2005). Much research has been devoted to identifying the pattern of leakage, as well as contributing factors, in an effort to stem the flow. Contextual factors such as classroom-level and family influences have been explored (e.g., Eccles, 1992; Eccles [Parsons], Kaczala, & Meece, 1982; Frenzel, Goetz, Pekrun, & Watt, 2010; Jacobs & Eccles, 1992; Leder, 1992; Leder, Forgasz, & Solar, 1996; Shapka & Keating, 2003), as have the gendered motivational and ability-based beliefs that influence educational and career decisions (e.g., Durik, Vida, & Eccles, 2006; Eccles, 2005; Larose et al., 2008; Simpkins & Davis-Kean, 2005; Watt, 2006, 2008; Watt, Eccles, & Durik, 2006). Much of this latter work has drawn upon the Eccles (Parsons) et al. (1983) expectancy-value motivational theory (see Eccles, 2005; Wigfield & Eccles, 2000); this is the framework that we used for the current study.

We explored longitudinally the relationships between math-related motivational beliefs (perceived math ability/success expectancy, intrinsic value, and attainment/utility value), high school math participation, and future educational and occupational aspirations for female and male adolescents. We incorporated data from three independent longitudinal studies, one conducted in Australia, another in Canada, and the third in the United States. These data allowed us to explore how earlier motivational beliefs about math (measured in Grades 9 and/or 10) impact later high school math participation and future aspirations (measured in Grades 11 and/or 12), across three culturally similar yet separate country settings, which differed in interesting ways.

The different systems afforded us the opportunity to examine the robustness of patterns across samples and settings—both in the identification of gender differences and in the ways in which motivational beliefs are implicated in educational and occupational outcomes. For example, in all three countries, students were allowed to choose the math courses they took through their final Grades 11 and 12 of high school, but the degree of freedom students could exercise varied across the countries. In New South Wales, in Australia, English was the only compulsory subject for students to take in Grades 11 and 12 when data were collected; most students chose to study math because it was prerequisite to certain university courses and was regarded favorably by potential employers. Students could choose one of five math courses, ranging from the least (Maths in Practice) to the most difficult (4-unit Maths), each spanning 2 years of study. The middle difficulty course (2-unit Maths) was prerequisite to certain university degrees, including engineering, medicine, accounting, aviation, and several science specializations; no university degrees required the highest or next highest math courses as prerequisites. Consequently, we anticipated that Australian students' choices would be based more on their intrinsic values.

In contrast, in the United States, most universities require algebra I, geometry, and algebra II (or trigonometry or calculus) for admission, as well as 4 years of language arts (e.g., literature, composition, English), 2 years of a foreign language, 3 years of science, and 3 years of social science. These requirements leave much less room for choices based on intrinsic interest. Similarly, course choice was more restricted in Ontario, Canada, when the data were collected, with students required to take language arts and at least six advanced courses. To enter the university, one of these had to be math in Grade 11; those wishing to enter scientific degree programs additionally needed advanced math in Grade 12. In both North American settings, less-difficult math courses, such as applied math or personal banking, could satisfy high school graduation requirements but not university admission requirements. Clearly, decisions regarding which math courses to take in high school are critical to remaining in the STEM pipeline for all three countries but in slightly different ways.

Career and Educational Aspirations

It is important to study career aspirations as well as course choices. Career aspirations during this developmental period are predictive of both educational attainment and eventual occupational choice (e.g., Farmer, Wardrop, Anderson, & Risinger, 1995; Lent, Brown, & Hackett, 1994; Schoon & Parsons, 2002; Webb, Lubinski, & Benbow, 2002; Wigfield & Eccles, 2000). There are two primary dimensions to the study of career-related aspirations: (a) the domain of study and type of occupation aspired to and (b) the amount of prestige associated with the aspired occupation (i.e., the social status or importance; Gottfredson, 1996). It is often assumed that individuals who pursue occupations outside STEM fields prefer occupations that have fewer educational requirements and are, consequently, less prestigious. However, it is quite possible that young men and women choose to pursue careers that are equally prestigious but not as mathematically intensive. For example, Farmer (1997) found that women who initially aspired to science-related careers but then shifted to nonscience interests a decade later had aspirations that remained as prestigious as their original, science-related aspirations (e.g., lawyer).

With this in mind, it is important to parse the prestige dimension of career aspirations from the domain of career to which individuals aspire. The current study is unique in that it explores both prestige and math-related dimensions simultaneously. We quantified both the math-relatedness of male and female adolescents' career intentions (see Watt, 2002, 2004, 2006, 2008) and the prestige level (see Shapka, Domene, & Keating, 2006, 2008). Parsing these dimensions provides insight into how they interrelate and how they are differentially predicted by motivational beliefs.

Gender Differences in Career Aspirations

The majority of the existing studies exploring gender differences in career aspirations has focused on the career type. Male adolescents are more likely than female adolescents to aspire to math-related careers (e.g., Watt, 2006, 2008). In contrast, female adolescents tend to aspire to careers that tap their social needs and involve interacting with people (e.g., Mullis et al., 1998; Wigfield & Eccles, 2002); that appear to be socially meaningful and important (e.g., Eccles & Vida, 2003); that relate to helping others, such as nursing; or that would be compatible with child-rearing responsibilities (Jozefowicz, Barber, & Eccles, 1993).

Regarding the prestige dimension of career aspirations, the existing literature examining gender differences is sparse. What does exist is quite mixed: Some research indicates the absence of gender differences (Armstrong & Crombie, 2000; Gassin, Kelly, & Feldhusen, 1993; Mau & Bikos, 2000; Watson, Quatman, & Edler, 2002); in other studies, female adolescents hold lower aspirations than do male adolescents (Mendez & Crawford, 2002; Wilson & Wilson, 1992); and in others, the reverse (Marjoribanks, 1986; Mau, 1995; Rojewski, 1997, 2002).

Gender Differences in Educational Aspirations

As with career prestige plans, research regarding gender differences among adolescents' educational aspirations has provided a mixed picture: In some studies, male adolescents reported higher educational aspirations (e.g., Inoue, 1999; Marini & Greenberger, 1978; Mendez & Crawford, 2002; Sewell, Hauser, & Wolf, 1980; Wilson & Wilson, 1992); in others, female adolescents did (Mahaffy & Ward, 2002; Mau, 1995; Mau & Bikos, 2000); and in still others, there was no gender difference (e.g., Garg, Kauppi, Lewko, & Urajnik, 2002). It has been argued that the more interesting issue is the *process* by which educational aspirations develop and influence other beliefs and intentions (Domene, Shapka, & Keating, 2006). The current article first explores gender differences across three samples from different countries and then examines motivational precursors to male and female adolescents' educational and career aspirations in each country.

Gender Differences in Secondary School Math Participation

A major source of leakage from the math pipeline occurs during the last years of high school, when students are given more freedom in course selection and many students opt out of math-related disciplines (Meece, 2006). Unfortunately, by abandoning advanced math, students restrict their educational and career options prematurely, particularly with regard to STEM fields (Bridgeman & Wendler, 1991).

Despite the fact that male and female adolescents achieve similar grades in mathematics (for recent meta-analyses see Hyde, 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008), gender differences in senior high math course enrollment are evident in the Australian (Leder, 1992; Leder et al., 1996; Watt, 2006, 2008) and Canadian (Shapka & Keating, 2003) settings, with fewer female than male adolescents acquiring sufficient advanced math background to be able to pursue STEM-related careers. However, the size of this gap has declined substantially in the United States (Updegraff, Eccles, Barber, & O'Brien, 1996); most school systems now require a greater number of math courses than previously, which has reduced the opportunity for female adolescents to drop out early in high school and may have helped close the gender gap (Snyder & Hoffman, 2001). Because achievement differences have been ruled out as the explanation, it is important to explore how motivational beliefs are impacting female and male adolescents' decisions. In the next section, we invoke the expectancy-value framework to describe the process by which this occurs.

Expectancy-Value Framework

Over the past 40 years, Eccles and her colleagues have developed and tested a comprehensive model that explains the social–cognitive processes that underlie both individual and gender differences in math and science participation (e.g., Eccles, 1994, 2005; Eccles [Parsons] et al., 1983; Wigfield & Eccles, 1992, 2000). The core premise of the model is that engagement in an activity can be predicted by the expectancy a person has for succeeding at it, as well as the value that she or he ascribes to the activity (Eccles, 2005; Wigfield, Battle, Keller, & Eccles, 2002). Extant work over the past several decades has provided support for this model; expectancies and different kinds of values predict math course enrollment and subsequent math achievement (e.g., Eccles, 1984; Eccles, 1985; Eccles [Parsons] et al., 1983; Watt, 2005; Wigfield, 1994).

Success expectancies can be operationalized in terms of beliefs about how well one will perform on an impending task and subjective ability beliefs (Eccles [Parsons] et al., 1983). The valuing of a task has been operationalized in terms of intrinsic value (likened to interest), utility value (which taps more extrinsic and instrumental values), and attainment value (the importance of doing well on a task, in order to confirm aspects of an individual's identity). Utility and attainment values are often combined and termed *importance value* (e.g., Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002).

Gender Differences in Motivation

Longitudinal studies across different countries have consistently identified gender differences favoring male adolescents, in their perceived mathematical ability or talent (Eccles et al., 1989; Frenzel et al., 2010; Jacobs et al., 2002; Nagy, Garrett, Trautwein, Cortina, & Eccles, 2008; Nagy et al., 2010; Shapka, 2009; Watt, 2004; Wigfield et al., 1997). Note that these gender differences exist despite a lack of disparity in corresponding math performance. Regarding the value placed on math, the literature exploring gender differences is slightly less straightforward. Researchers who have examined composite math values have found they do not differ as a function of gender (e.g., Jacobs et al., 2002); researchers exploring the disaggregated components of math value (e.g., intrinsic vs. utility value) have found that male adolescents report higher interest in math (e.g., Frenzel et al., 2010; Watt, 2004), although male and female adolescents regard math as equally useful (Watt, 2004). Given that expectancy-value motivational constructs predict high school math participation over and above math achievements (e.g., Shapka & Keating, 2003; Watt et al., 2006), gender differences in these beliefs are likely to contribute to the proportionally higher leakage of female adolescents from the pipeline during high school.

Gendered Motivational Processes

Much of the research in this area has focused on mean differences between genders on various motivational predictors or achievement-related outcomes (Simpkins & Davis-Kean, 2005), including longitudinal exploration of the development and persistence of gender differences (e.g., Frenzel et al., 2010; Jacobs et al., 2002; Nagy et al., 2010; Shapka, 2009; Shapka & Keating, 2003; Watt, 2004; Wigfield et al., 1997). Understanding the relationship between motivational beliefs and outcomes for male and female adolescents is critical to understanding potential gendered mechanisms that lead to math participation or disengagement (Eccles, 2009; Simpkins & Davis-Kean, 2005). For example, Eccles and her colleagues have demonstrated that female adolescents are engaged by tasks they regard as important (e.g., Eccles & Vida, 2003). This implies that female adolescents who regard math as important to them are more likely to aspire to further math participation, perhaps more so than is the case for male adolescents. Whether gender moderates relationships in such ways has important theoretical and practical consequences for intervention.

The Current Study

Our study first examined gender differences among expectancy-value motivational beliefs (ability/success expectancy, intrinsic value, attainment/utility value), senior high math course participation, aspired level of education, planned math-related career, and planned career prestige. Next, we sought explanations for male and female adolescents' educational and occupational aspirations in terms of which motivational factors predicted which outcomes, as well as how the different outcomes themselves interrelated. Three independent but similar longitudinal data sets collected in Australia, Canada, and the United States were employed to answer these questions.

Based on the preceding review, we hypothesized the following:

> *Hypothesis 1:* Gender differences would favor male adolescents for math-related motivations where they occurred. Based on previous literature, we anticipated male adolescents would have higher ability/success expectancy and intrinsic value for math but that there would be no gender differences on attainment/utility value (Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002; Nagy et al., 2010; Watt, 2004).

> *Hypothesis 2:* Gender differences in high school math participation would be more pronounced for the Australian sample than for the U.S. or Canadian sample, because college-bound students in the United States and Canada would likely perceive more negative consequences of opting out of math (see Watt, Eccles, & Durik, 2006). Male adolescents would have higher senior high math course participation and math-related career plans, when gender differences occurred.

> *Hypothesis 3:* Intrinsic value would play a greater role in Australian students' senior high math course choices, due to the different course selection structure and university admission requirements.

> *Hypothesis 4:* Attainment/utility ("importance") value would play a greater role for female than male adolescents in their career choice based on evidence that female adolescents are attracted to careers they regard as personally meaningful and important.

> *Hypothesis 5:* Math course participation in senior high would predict math-related career plans, in line with the pipeline metaphor.

> *Hypothesis 6:* Math-related career plans would relate to the prestige dimension of career plans, perhaps more strongly for male than female adolescents in view of evidence that women who pursue STEM careers tend to pursue careers of lower status.

Based on previous literature, we did not have firm hypotheses concerning whether, and the extent to which, gender differences would occur for aspired level of education and career prestige plans or whether prior motivational beliefs related to math or senior high school math courses would predict "nonmathematical" educational and occupational outcomes.

Method

Samples and Settings

Data were from three separate, longitudinal projects in Australia, Canada, and the United States. Each involved multiple cohorts and a shared interest in examining adolescent development within school contexts. Included in this was an investigation of math-related motivations, as well as educational and occupational aspirations. In addition to their shared focus, the sample characteristics for each of the projects were remarkably similar—participants from each study were from suburban middle to upper-middle socioeconomic backgrounds and were primarily of Anglo-European descent.

Australian sample. Data were from the Study of Transitions and Education Pathways (STEPS; Watt, 2004; www.stepsstudy.org). Participants attended one of three coeducational government secondary schools matched for socioeconomic status in northern metropolitan Sydney. Participants for the current study were the eldest STEPS cohort ($N = 358$; 43.3% female; 97.77% sample retention across both time points), surveyed at the commencement of Grades 9, 10, and 11; data from Waves 1 and 3, collected in 1996 and 1998, were utilized for the current study.

Canadian sample. Participants in the Canadian Adolescent Development and Educational Transitions (CADET) project (Shapka, 2009; Shapka & Keating, 2003) were drawn from two public high schools in Ontario, Canada. Both were in the same school board jurisdiction, matched for socioeconomic status and consisting of college-bound youths. Participants for the current study included the two youngest CADET cohorts ($N = 471$; 51.6% female; 98.09% sample retention across both time points). Participants were in Grade 9 or 10 at Wave 1 in 1994/1995 and in Grade 11 or 12 at Wave 2 in 1996/1997. Self-report questionnaires were completed by students in groups during the spring school term.

U.S. sample. Data were from the Childhood and Beyond Study (CAB; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Wigfield, Eccles, MacIver, Reuman, & Midgley, 1991), which drew participants who were attending public schools and living in the suburbs of a large midwestern city in the United States. For the present study, participants provided data at each of Grades 10 (in 1994/1996) and 12 (in 1996/1998) during the spring of each year. The current study included the two eldest CAB cohorts ($N = 418$;

53.8% female; 66.75% sample retention across both time points) because data were not collected from the youngest cohort in Grade 10.

Measures

Math motivational beliefs. For all three data sets, math-related motivations were measured in Grade 9 (Australia, Canada) and/or 10 (Canada, United States) using Eccles and colleagues' expectancy-value measures, measured on 7-point Likert-type scales (see Eccles, 2005; Wigfield & Eccles, 2000). There were grammatical and contextualizing modifications for the Australian sample (discussed in Watt, 2004) and omissions from the full instrument for the Canadian sample, but each data set included items tapping perceived ability, success expectancy, intrinsic value, attainment value, and utility value. Given idiosyncrasies for each study, described in the next section, initial unconstrained multigroup confirmatory factor analyses (CFAs) examined the construct validity for expectancy-value constructs for male and female adolescents, within each sample. In these analyses, items were specified as indicators only for their respective factors; error variances and factor correlations were freely estimated; and no error covariances were specified, except in the Canadian CADET sample for the two items tapping intrinsic value, which contained parallel wording (see Table 1). These items were additionally constrained to load equally, and item variances were constrained to be equal across gender groups after checking similar variance estimates, in order to identify the intrinsic value construct. The item stems and rating responses, along with Cronbach's alpha measures of internal consistency, are in Table 1 for each of the samples.

High school math participation. In the State of New South Wales, Australia, math was compulsory until the end of Grade 10, after which students chose the difficulty level they studied in the final 2 years of high school. Although no longer compulsory, the overwhelming majority of students chose to study math through Grades 11 and 12. Math coursework selections were hierarchically organized according to course demand and difficulty (MacCann, 1995), from the lowest to highest (Maths in Practice [MIP], Maths in Society [MIS], 2-unit, 3-unit, and 4-unit); a 2-unit math level was prerequisite to several university degrees. In the current study, a 4-point scale was used (1 = *MIP/MIS*, 2 = *2-unit*, 3 = *3-unit*, 4 = *4-unit*) due to negligible frequencies in the lowest recently introduced course. This naturally occurring ordered metric provided a measure of students' participation in increasingly complex math in senior high school.

In the Canadian sample, math participation was represented by the number of advanced math courses undertaken through the final years of high school (Grades 11 and 12), calculated from school record data and averaged for the elder cohort. All students were required to take the same math courses until the end of Grade 10; they subsequently had the option of opting out of math or choosing basic (e.g., accounting, business math) or advanced math courses (i.e., algebra, geometry, calculus, finite math). In this Ontario sample, college- or university-bound students had to take at least one advanced math course in Grade 11 or 12 to meet university entry requirements. Those wishing to enter degree programs such as science, math, technology, or economics additionally needed to take Grade 12 advanced math.

In the United States sample, math participation was represented by the total number of math courses taken through Grades 11 and 12, calculated from school record data (high missing data, 204 valid cases). During Grades 9–12, students chose which math courses they wanted to study. Most schools required at least 2 years of math and strongly recommended that students who aimed to attend college take more. Similar to the Canadian setting, and unlike the Australian setting, courses were organized by topic area, some of which were generally regarded as less difficult (e.g., general math, beginning algebra) and others as more difficult (e.g., calculus, trigonometry), although there was no formal classification. Consequently, more math courses did not necessarily imply participation in increasingly difficult math.

Educational and occupational aspirations. For all three samples, when students were in Grades 11 (Australia, Canada) and/or 12 (Canada, United States), they were asked to list their educational and occupational aspirations via open-ended questions. Educational aspirations were coded from lowest to highest on 4-point scales: 1 (*high school*), 2 (*technical or community college*), 3 (*university/4-year college*), and 4 (*graduate or professional degree*); we combined Categories 3 and 4 in the Australian sample, and Categories 1 and 2 in the United States sample, due to lack of responses in each instance (see Table 4).

Occupational aspirations were coded for both math-relatedness and prestige level, per nominated career. Because not all students yet had a career in mind, occupational data were available for 288 Australian, 431 Canadian, and 256 United States participants (respectively, representing 82.29%, 93.29%, and 88.17% of participants present at the second time point per sample). Using the O*NET (Occupational Information Network) database (U.S. Department of Labor Employment and Training Administration, 1998), we quantified math-related career plans into one of four ordered categories labeled "no," "any," "average," or "high" mathematical content. The O*NET database classifications were also used to quantify occupational prestige on a scale ranging from 1 (*lowest*) to 5 (*highest*). This prestige score is derived from several different factors, including average estimated wage for the occupation across the United States and types and amount of experience and education required for the occupation. Descriptive statistics for observed constructs within each sample can be found in Table 2.

Data Analyses

Analyses were conducted within the multiple-group mean and covariance structures framework using Amos 19.0 (emulisrel6 option selected). This is an extension of traditional structural equation modeling, in which mean-level information as well as the covariance matrix is analyzed. Strong factorial invariance (Little, 1997; Meredith, 1993) implies that constructs are fundamentally the same across groups and are consequently directly comparable. Strong factorial invariance is tenable when equality constraints for factors' loading and intercept parameters hold, which is determined when the sequential introduction of those constraints does not produce substantial change in model fit. Sequential constraints were thereby imposed to determine qualitative construct equivalence for latent ability/success expectancy, intrinsic value, and attainment/utility value motivational constructs before quantitative exploration could be meaningfully undertaken between gender

Table 1
Time 1 CFA Completely Standardized Factor Loadings (LX) and Cronbach's Alpha Reliabilities per Sample

Sample, construct (α), and item	Item stem	LX	
		Female	Male
	Australia[a]		
Abil_Exp (α = .89)			
Abil1	Compared with other students in your class, how talented do you consider yourself to be at maths?	.63	.61
Abil2	How talented do you think you are at maths?	.48	.64
Exp1	How well do you expect to do in your next maths test?	.87	.82
Exp2	How well do you expect to do in school maths tasks this term?	.88	.88
Exp3	How well do you think you will do in your school maths exam this year?	.85	.84
Intrin (α = .94)			
Intrin1	How much do you like maths, compared with your other subjects at school?	.86	.88
Intrin2	How interesting do you find maths?	.91	.94
Intrin3	How enjoyable do you find maths, compared with your other school subjects?	.97	.95
Att_Util (α = .89)			
Att1	To what extent will you need maths in your future work/career?	.91	.88
Att2	How important is doing well in maths to you?	.85	.88
Util1	How useful do you believe maths is?	.87	.84
Util2	How useful do you think maths is in the everyday world?	.70	.74
Util3	How useful do you think mathematical skills are in the workplace?	.60	.71
	Canada[b]		
Abil_Exp (α = .93)			
Abil1	How good at math are you?	.90	.91
Abil2	If you were to rank all the students in your math class, where would you put yourself?	.89	.84
Abil3	Compared to most of your other school subjects, how good are you at math?	.84	.83
Abil4	When taking a test that I studied for, I do: (very poorly, very well)	.80	.73
Exp1	How successful do you think you'd be in a career requiring mathematical ability?	.84	.83
Exp2	How well do you think you will do in math this year?	.86	.80
Intrin (α = .89)			
Intrin1	I have had quite a few interesting assignments in math to do at home.	.86	.83
Intrin2	I have had quite a few interesting assignments in math to do at school.	.88	.78
Att_Util (α = .77)			
Att1	In terms of my adult life, it is not important for me to do well in math in high school.	.47	.36
Att2	I expect to have little use for math when I get out of school.	.57	.71
Att3	How useful do you think the math you are learning will be for what you want to do after you graduated and go to work?	.63	.70
Att4	How important is training or education in math for the job or career that you would most like to have?	.48	.34
Util1	Taking math is a waste of time.[c]	.73	.78
Util2	Math is a worthwhile and necessary subject.	.74	.82
	United States[d]		
Abil_Exp (α = .92)			
Abil1	If you were to list all the students in your grade from worst to best in math, where would you put yourself?	.89	.78
Abil2	How good at math are you?	.91	.90
Exp1	How well do you expect to do in math next year?	.81	.84
Exp2	How good would you be at learning something new in math?	.84	.87
Intrin (α = .88)			
Intrin1	How much do you like doing math?	.92	.89
Intrin2	In general, I find working on math assignments: (very boring, very interesting)	.80	.74
Intrin3	Compared to other activities, how much do you like math?	.94	.82
Att_Util (α = .80)			
Att1	For me, being good at math is: (not at all important, very important)	.82	.75
Att2	Compared to other activities, how important is it to you to be good at math?	.72	.72
Util1	In general, how useful is what you learn in math?	.67	.71
Util2	Compared to other activities, how useful is what you learn in math?	.67	.66

Note. Measurement errors are not presented. CFA = confirmatory factor analysis; Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value.
[a] All anchors ranged from 1 (*not at all*) to 7 (*very*). Latent intercorrelations: female adolescents: $\Phi_{1,2}$ = .35, $\Phi_{1,3}$ = .23, $\Phi_{2,3}$ = .57; male adolescents: $\Phi_{1,2}$ = .56, $\Phi_{1,3}$ = .45, $\Phi_{2,3}$ = .55. [b] Abil_Exp items anchored ranged from 1 (*not at all*) to 7 (*very*); Intrin1–2 and Util1–2 items from 1 (*strongly disagree*) to 5 (*strongly agree*); Att1–2 items from 1 (*strongly agree*) to 5 (*strongly disagree*); Att–3 from 1 (*not at all*) to 7 (*very useful*); Att4 from 1 (*very unimportant*) to 7 (*very important*). Latent intercorrelations: Intrin1–2 freed error covariance = .16 female adolescents and .43 male adolescents; female adolescents: $\Phi_{1,2}$ = .30, $\Phi_{1,3}$ = .41, $\Phi_{2,3}$ = .29; male adolescents: $\Phi_{1,2}$ = .26, $\Phi_{1,3}$ = .55, $\Phi_{2,3}$ = .33. [c] Item was reverse-coded. [d] All anchors ranged from 1 to 7 with varying anchor labels (most often *not at all, very*). Latent intercorrelations: female adolescents: $\Phi_{1,2}$ = .70, $\Phi_{1,3}$ = .62, $\Phi_{2,3}$ = .76; male adolescents: $\Phi_{1,2}$ = .69, $\Phi_{1,3}$ = .60, $\Phi_{2,3}$ = .73.

Table 2
Descriptive Statistics for Observed Study Variables per Sample

Country and sample	Aspired career: Math relatedness	Aspired career: Prestige	High school math participation	Educational aspiration
Australia				
Total *M* (*SD*)	1.46 (1.06)	4.03 (0.94)	2.07 (0.92)	2.80 (0.55)
Male adolescents *M* (*SD*)	1.61_a (1.03)	4.06 (0.84)	2.20_b (0.93)	2.71 (0.67)
Female adolescents *M* (*SD*)	1.23_a (1.07)	3.97 (1.04)	1.91_b (0.88)	2.77 (0.60)
Range	0–3	1–5	1–4	1–3
Canada				
Total *M* (*SD*)	1.29 (0.95)	3.94 (0.89)	0.86 (0.64)	2.90 (0.79)
Male adolescents *M* (*SD*)	1.36 (1.03)	3.96 (0.90)	0.84 (0.63)	2.84 (0.78)
Female adolescents *M* (*SD*)	1.22 (0.87)	3.93 (0.88)	0.87 (0.65)	2.96 (0.80)
Range	0–3	1–5	1–3	1–4
United States				
Total *M* (*SD*)	1.58 (1.03)	4.30 (0.80)	3.06 (1.11)	3.44 (0.63)
Male adolescents *M* (*SD*)	1.64 (1.11)	4.31 (0.85)	3.08 (1.11)	3.37 (0.60)
Female adolescents *M* (*SD*)	1.54 (0.97)	4.29 (0.76)	3.04 (1.11)	3.49 (0.64)
Range	0–3	1–5	1–4	2–4

Note. Paired subscripts indicate statistically significant gender differences.

groups within each sample. Only in this case is it justified to compare motivations from different groups on the same measures and to interpret gendered relationships identified in full structural equation models (SEMs) that could otherwise be due to gender differences within the measurement models. Because popular approaches to missing data, such as mean substitution and listwise and pairwise deletion, can bias results (Allison, 2001), full-information maximum likelihood (Arbuckle, 1996) estimation was used in all SEM analyses in order to include all of the observed data, based on the missing at random assumption.

Measurement models. Measurement equivalence indicates that constructs are generalizable to each of the groups; that sources of bias and error are minimal; that gender differences have not differentially affected the constructs' underlying measurement characteristics; and that between-gender differences in construct means, variances, and covariances are quantitative in nature. The sequence of analyses involves, first, a combined multiple-group model with no cross-group equality constraints for the three latent constructs for male and female adolescents in each of the three country samples (Model 1); second, the addition of the constraint that loadings are invariant across samples (Model 2); and third, constraints that loadings as well as intercepts are equivalent across samples (Model 3: the Measurement Equivalent Model; Little, 1997). Nested models are compared according to change in the chi-square statistic relative to change in degrees of freedom; significant worsening of model fit indicates that the imposed model constraints are not tenable. Because the chi-square comparison is highly stringent and sensitive to sample size, Little (1997) recommended inspection of changes in practical fit indices, with a margin of .05 indicating acceptable model similarity to proceed with the introduced constraints. When Model 3 does not hold, *partial scalar invariance* may be acceptable, where those intercepts that are tenable to constrain across groups are held constant.

Gender differences in motivation. Quantitative gender differences were compared for the Time 1 expectancy-value latent constructs (ability/success expectancy, intrinsic value, attainment/utility value) by constraining latent means to zero for male adolescents as the reference group in each sample, such that the freely estimated latent means for female adolescents produced the effect sizes, corrected for measurement error.

Gendered motivational processes. Multigroup SEMs were estimated to examine processes by which prior motivational factors influenced male and female adolescents' educational and occupational outcomes in senior high school by adding the four single-item dependent variables to the final constrained CFAs in each sample. Because the four outcome variables were each measured by a single question, those item loadings were fixed to unity and error variances to zero. All indicators of the predictor variables were specified as continuous, and the four outcome variables as ordinal.

Structural paths initially estimated for every model included those from Time 1 motivational factors (ability/success expectancy, intrinsic value, and attainment/utility value) to each of the Time 2 outcome variables (math courses, aspired level of education, planned mathematics-related career, and planned career prestige); from math courses to each of the other three outcome variables (aspired level of education, planned mathematics-related career, planned career prestige); from aspired level of education to planned mathematics-related career and career prestige; and from planned mathematics-related career to planned career prestige. Within each model, structural paths that were nonsignificant for both female and male adolescents ($p > .05$) were sequentially deleted to achieve the final models, identical for male and female adolescents.

To identify where different gender processes occurred, structural paths were sequentially constrained to equality in each sample. When the change in chi-square value, relative to the single degree of freedom change, exceeded the critical value (3.841, $p < .05$), the assumption of equivalent relationship was not tenable, indicating statistically significantly different structural relationships for male and female adolescents.

Gender differences in educational and occupational outcomes. Multivariate analyses of variance determined the extent to which gender differences occurred for the four observed dependent variables (Time 2: math courses, aspired level of education, planned math-related career, planned career prestige) per sample.

Results

Measurement Models

Unconstrained multigroup CFAs (Model 1) showed adequate model fits within each of the three samples across a range of frequently emphasized fit statistics for the latent expectancy-value constructs ability/success expectancy, intrinsic value, and attainment/utility value (Australia: χ^2 = 361.958, *df* = 124, root-mean-square error of approximation [RMSEA] = .073, Tucker–Lewis index [TLI] = .896, comparative fit index [CFI] = .929; Canada: χ^2 = 440.416, *df* = 148, RMSEA = .065, TLI = .841, CFI = .921; United States: χ^2 = 263.730, *df* = 82, RMSEA = .073, TLI = .901, CFI = .939). Factor loadings, which were all statistically significant, are presented for each of the three samples in Table 1.

Model fits for sequential constrained Models 1 through 3 for each of the latent constructs are shown in Table 3. In each sample, for Models 1 and 2 (the unconstrained and loadings-invariant models) fit statistics were acceptable and the change in chi-square was not statistically significant. However, Model 3 (loadings and intercepts invariant) could not be accepted in any of the samples due to poor model fit (Australia: χ^2 = 1,607.990, *df* = 150, RMSEA = .165, TLI = .473, CFI = .566; Canada: χ^2 = 2,027.160, *df* = 176, RMSEA = .150, TLI = .406, CFI = .502; United States: χ^2 = 1,494.649, *df* = 104, RMSEA = .179, TLI = .403, CFI = .529). A series of submodels was therefore estimated within each sample to determine which intercepts could be validly constrained across gender groups; the others were freely estimated (see Table 4). The new resultant Model 3 (partial scalar invariance), although exhibiting significant change in chi-square relative to Model 2, showed small changes in practical fit indices across sequentially constrained models (ΔTLI = .006 between Models 1a and 3a in the Australian, .007 between Models 1b and 3b in the Canadian, and .011 between Models 1c and 3c in the United States samples; see Table 3), well below the .05 margin referred to by Little (1997). The condition of partial scalar invariance was therefore met (e.g., Byrne, 2010), indicating that quantitative comparisons of factor scores could be meaningfully undertaken across gender groups.

Gender Differences

Motivational beliefs. With the condition of partial scalar invariance met, the latent factor means estimated in the final Model 3 that significantly differed between male and female adolescents could be estimated. Because latent means were set to zero for male adolescents, the latent means for female adolescents represent the latent mean difference relative to male adolescents (see Table 4). In the Australian sample, female adolescents had significantly lower intrinsic value than did male adolescents (estimate = –.563, p = .002), and their lower ability/success expectancy approached significance (estimate = –.159, p = .070); in each of the Canadian and U.S. samples, female adolescents had significantly lower ability/success expectancy than did male adolescents (Canada: estimate = –.394, $p < .001$; United States: estimate = –.295, p = .052). Table 4 additionally shows the item intercepts for each of male and female adolescents.

Educational and occupational outcomes. Gender differences in educational and occupational outcomes emerged only among the Australian sample; there was a significant multivariate effect on the outcome variables (math courses, aspired level of education, planned math-related career, planned career prestige), Pillai's trace, $F(4, 275) = 4.894$, $p < .001$, partial η^2 = .066. This was accounted for by significant pairwise differences in high school math participation (mean difference = .394, *SE* = .105, $p < .001$) and math-related career plans (mean difference = .375, *SE* = .126, p = .003), based on comparisons of estimated marginal means for male and female adolescents and Bonferroni adjustment for multiple comparisons. In contrast, there were no significant multivariate or pairwise effects within either of the North American samples.

Table 3
Fit Statistics for Sequential Constrained Models

Country and model	χ^2	*df*	RMSEA	CFI	TLI	$\Delta\chi^2/df$	ΔCFI	ΔTLI
Australia: STEPS								
1a: Freely estimated	361.958	124	.073	.929	.896			
2a: Loadings invariant	371.871	134	.071	.929	.904	9.913/10	.000	–.008
3a: Partial scalar invariance	395.675	141	.071	.924	.902	23.804/7[a]	.005	.002
Canada: CADET								
1b: Freely estimated	440.416	148	.065	.921	.888			
2b: Loadings invariant	450.689	159	.063	.922	.896	10.273/11	–.001	–.008
3b: Partial scalar invariance	477.612	167	.063	.917	.895	26.923/8[a]	.005	.001
United States: CAB								
1c: Freely estimated	263.730	82	.073	.939	.901			
2c: Loadings invariant	267.731	90	.069	.940	.912	4.001/8	–.001	–.011
3c: Partial scalar invariance	290.663	98	.069	.935	.912	22.932/8[a]	.005	.000

Note. RMSEA = root-mean-square error of approximation; CFI = comparative fit index; TLI = Tucker–Lewis index; STEPS = Study of Transitions and Education Pathways; CADET = Canadian Adolescent Development and Educational Transitions; CAB = Childhood and Beyond Study.
[a] There was a statistically significant change in chi-square ($p < .05$).

Table 4
Factor Solution for Partial Scalar Invariance Model: Item Intercepts (TX), Factor Loadings (LX), Latent Means (KA)

Country, factor, and item	TX	LX	KA[a]	p[b]
Australia				
Abil_Exp			–.159	.070
Abil1[c]	4.545	1.000		
Abil2	4.344	.885		
Exp1	5.015	1.323		
Exp2[d]	5.079	1.385		
Exp3[d]	5.044	1.304		
Intrin			–.563	.002
Intrin1[d]	3.837	.885		
Intrin2[d]	4.134	.960		
Intrin3[c]	3.903	1.000		
Att_Util			.009	.933
Att1	4.381	1.197		
Att2[c]	5.331	1.000		
Util1[d]	5.242	1.485		
Util2[d]	5.087	1.450		
Util3[d]	5.195	1.296		
Canada				
Abil_Exp			–.394	<.001
Abil1[c]	5.538	1.000		
Abil2	5.169	.898		
Abil3[d]	5.121	1.098		
Abil4[d]	5.905	.806		
Exp1	5.257	1.000		
Exp2[d]	5.657	.879		
Intrin			–.130	.244
Intrin1[d]	2.525	.966		
Intrin2[c]	2.748	1.000		
Att_Util			.031	.575
Att1[d]	3.937	.981		
Att2[d]	3.845	1.460		
Att3	3.679	1.361		
Att4[c]	3.717	1.000		
Util1[d]	4.510	1.333		
Util2[d]	4.454	1.382		
United States				
Abil_Exp			–.295	.052
Abil1[c]	4.984	1.000		
Abil2[d]	5.413	1.139		
Exp1[d]	5.415	.913		
Exp2[d]	5.372	1.002		
Intrin			–.079	.694
Intrin1[d]	4.006	1.083		
Intrin2[d]	3.550	.853		
Intrin3[c]	3.487	1.000		
Att_Util			.003	.983
Att1[d]	5.225	1.229		
Att2[c]	4.351	1.000		
Util1[d]	4.376	1.158		
Util2[d]	4.122	1.002		

Note. Parameter estimates are presented in unstandardized form, and uniquenesses are not presented. Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value.
[a] Ratio of female to male adolescents relative to the male adolescents as reference group in the original metric, per sample. [b] Critical ratio. [c] Indicators of each construct were fixed to 1 to establish the factor metric, and in the case of Intrin in the Canadian Adolescent Development and Educational Transitions sample, gammas were constrained to equally contribute and the error covariance was estimated. [d] Intercepts constrained to be equal across gender groups.

Gendered Motivational Processes

Australian sample. The multigroup final structural equation model (SEM), including partial scalar invariance constraints for female and male adolescents, exhibited satisfactory model fit across a range of frequently emphasized indices ($\chi^2 = 533.439$, $df = 239$, RMSEA = .059, TLI = .899, CFI = .921). For both female and male adolescents in the Australian STEPS sample, prior math motivation directly impacted senior high level of math enrollment and aspired level of education and indirectly impacted planned career prestige. For female adolescents, motivation additionally directly impacted planned mathematics-related career, whereas for male adolescents, the motivational effects were indirect. Intrinsic and attainment/utility values exerted direct influences; ability/success expectancy influences were indirect in their influence. Sequential comparison of structural paths for female and male adolescents identified a significant difference in the impact of intrinsic value on educational aspirations, indicated by significant change in chi-square relative to degrees of freedom when this path was constrained to be equal across gender groups. Latent correlations between all constructs are shown in Table 5 for each of the six models.

Completely standardized paths for the final model for female adolescents are shown in Figure 1. Female adolescents' Grade 9 math motivation was moderately related for intrinsic and attainment/utility values ($\Phi = .57$), but there were weaker relationships between intrinsic value and ability/success expectancy ($\Phi = .35$) and between attainment/utility value and ability/success expectancy ($\Phi = .23$). Attainment/utility value significantly and positively predicted aspired level of education ($\gamma = .24$) and mathematics-related career plan ($\gamma = .21$); intrinsic value significantly predicted math course level ($\gamma = .45$) and aspired level of education ($\gamma = -.42$). Math course level predicted aspired level of education ($\beta = .39$), planned mathematics-related career ($\beta = .38$), and career prestige ($\beta = .21$). Aspired level of education predicted only the career prestige dimension ($\beta = .21$), which was also predicted by mathematics-related career plans ($\beta = .39$). The negative coefficient between intrinsic value and aspired level of education reflected a negative, although weaker, bivariate correlation between these two constructs for female adolescents (–.11), seemingly indicating that female adolescents who held higher intrinsic value for math but who did not undertake advanced math coursework in senior high school were less likely to aspire to university qualifications.

For male adolescents (see Figure 1), intrinsic and attainment/utility values were also moderately related ($\Phi = .55$), as were intrinsic value and ability/success expectancy ($\Phi = .56$), as well as attainment/utility value and ability/success expectancy ($\Phi = .45$). As with the female adolescents, intrinsic value significantly predicted math course level ($\gamma = .48$). Attainment/utility value positively predicted aspired level of education ($\gamma = .25$) but did not significantly predict mathematics-related career plan. Math course level predicted aspired level of education ($\beta = .21$) and planned mathematics-related career ($\beta = .39$) but not career prestige. Aspired level of education predicted only the career prestige dimension ($\beta = .16$), which was also impacted by mathematics-related career plans ($\beta = .55$).

Canadian sample. The final constrained multigroup SEM for the Canadian CADET sample showed satisfactory model fit ($\chi^2 =$

Table 5
Latent Correlations Between Constructs as a Function of Sample and Gender

Country and measure	1	2	3	4	5	6
Australia						
1. Att_Util	—					
2. Abil_Exp	.45/.24	—				
3. Intrin	.55/.57	.56/.36	—			
4. Math_Part	.26/.26	.27/.17	.48/.45	—		
5. Ed_Asp	.40/.10	.26/−.03	.41/−.11	.36/.26	—	
6. Job_Math	.24/.31	.17/.11	.26/.29	.42/.44	.19/.12	—
7. Job_Prest	.21/.20	.15/.07	.23/.19	.34/.44	.29/.31	.60/.51
Canada						
1. Att_Util	—					
2. Abil_Exp	.55/.40	—				
3. Intrin	.33/.28	.25/.30	—			
4. Math_Part	.41/.18	.52/.55	.16/.16	—		
5. Ed_Asp	.27/.24	.29/.29	.10/.11	.51/.43	—	
6. Job_Math	.15/.29	.15/.16	.06/.09	.25/.14	.18/.23	—
7. Job_Prest	.13/.18	.13/.16	.05/.07	.23/.20	.33/.43	.42/.43
United States						
1. Att_Util	—					
2. Abil_Exp	.60/.62	—				
3. Intrin	.73/.76	.68/.69	—			
4. Math_Part	.24/.55	.39/.48	.27/.47	—		
5. Ed_Asp	.23/.23	.38/.37	.25/.26	.15/.18	—	
6. Job_Math	.07/.02	.11/.03	.07/.02	.04/.01	.29/.08	—
7. Job_Prest	.07/.06	.11/.10	.07/.07	.04/.05	.29/.26	.44/.37

Note. Correlations for male/female adolescents. Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value; Math_Part = high school math participation; Ed_Asp = educational aspiration; Job_Math = aspired career math relatedness; Job_Prest = aspired career prestige.

609.111, *df* = 273, RMSEA = .051, TLI = .899, CFI = .919). Unlike in the Australian sample, ability/success expectancy emerged as a key motivational influence on subsequent number of advanced math courses for both female and male adolescents, whereas intrinsic value exerted no direct effects. Attainment/utility value additionally predicted math-related career plans for female adolescents and advanced math course taking for boys; these relationships significantly differed for gender groups, as indicated by nested chi-square comparisons.

Female adolescents' Grade 9 math motivation was moderately interrelated for intrinsic and attainment/utility values (Φ = .41), as well as for attainment/utility value and ability/success expectancy (Φ = .41), but was more weakly interrelated for intrinsic value and ability/success expectancy (Φ = .30). Ability/success expectancy at Grade 9/10 positively predicted number of math courses undertaken in Grades 11/12 (γ = .57); attainment/utility value directly predicted aspired level of education (γ = .16) and math-related career plans (γ = .24). Number of math courses predicted aspired level of education (β = .40), which in turn predicted plans for math-related career (β = .16) and career prestige (β = .35). Planned math-related career also predicted the prestige dimension of aspired career (β = .35; see Figure 2).

For male adolescents (see Figure 2), attainment/utility value and ability/success expectancy were again moderately related (Φ = .55), intrinsic and attainment/utility values less so (Φ = .33), and intrinsic value and ability/success expectancy showed a weaker relationship (Φ = .26). Similar to Canadian female adolescents, for Canadian male adolescents, grade 9/10 ability/success expectancy positively predicted average number of advanced math courses undertaken in grades 11/12 (γ = .42), as did attainment/utility value (γ = .18). Average number of advanced math courses again predicted aspired level of education (β = .47); additionally average number of math courses directly predicted math-related career plans (β = .19). Aspired level of education predicted only the prestige dimension of career plans (β = .26), also predicted by math-related career plans (β = .37).

U.S. sample. As with the Canadian sample, ability/success expectancy emerged as a key motivational influence among the U.S. CAB sample, impacting number of math courses and aspired level of education for both female and male adolescents. Intrinsic value again exerted no direct effects; attainment/utility value predicted number of math courses taken for female adolescents only, and this coefficient significantly differed for gender groups, as indicated by nested chi-square comparisons. Again the SEM exhibited acceptable fit (χ^2 = 398.727, *df* = 186, RMSEA = .052, TLI = .912, CFI = .932); the high latent correlations among predictor variables in this sample may produce collinearities among the structural paths.

In the model for U.S. female adolescents (see Figure 3), Grade 10 math motivation was highly interrelated: Φ = .76 for intrinsic value and attainment/utility value, Φ = .62 for attainment/utility value and ability/success expectancy, and Φ = .69 for intrinsic value and ability/success expectancy. As with Canadian female adolescents, ability/success expectancy signif-

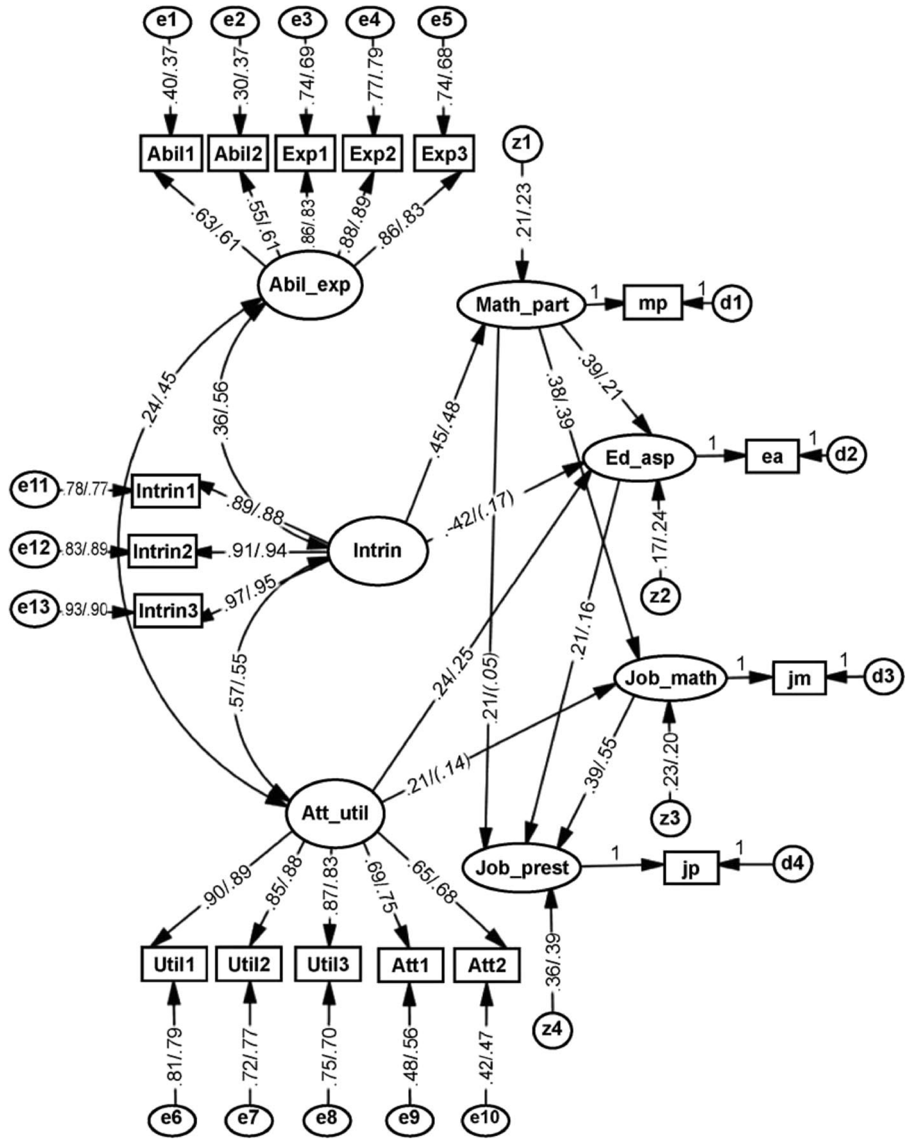

Figure 1. Structural path model diagram for the Australian Study of Transitions and Education Pathways for female and male adolescents. Paired parameters indicate standardized estimates for female/male adolescents, and nonsignificant structural paths are indicated in italics in parentheses ($p > .05$). Rectangular boxes denote observed data; ovals denote latent constructs. One-directional arrows denote predictive paths; curved two-directional arrows denote correlations. Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value; Math_Part = mp = high school math participation; Ed_Asp = ea = educational aspiration; Job_Math = jm = aspired career math-relatedness; Job_Prest = jp = aspired career prestige; e1–e13 = measurement errors for exogenous construct item indicators; d1–d4 = measurement errors for endogenous construct item indicators; z1–z4 = endogenous construct disturbances.

icantly and positively predicted number of math courses (γ = .23) and aspired level of education (γ = .37). Attainment/utility value predicted number of math courses taken (γ = .40). Aspired level of education and math-related career plans each uniquely predicted the prestige dimension of career plans (β = .23 and β = .36, respectively).

For male adolescents (see Figure 3), motivational constructs were again highly interrelated: Φ = .72 for intrinsic value and attainment/utility value, Φ = .60 for attainment/utility value and ability/success expectancy, and Φ = .67 for intrinsic value and ability/success expectancy. As with U.S. female adolescents (and similar to Canadian female and male adolescents), Grade 10 ability/success expectancy positively predicted number of math courses subsequently taken (γ = .38) and aspired level of education (γ = .38). Unlike the case with female adolescents, aspired level of education directly predicted math-related career plans (β = .29), which in turn predicted prestige career plans (β = .39).

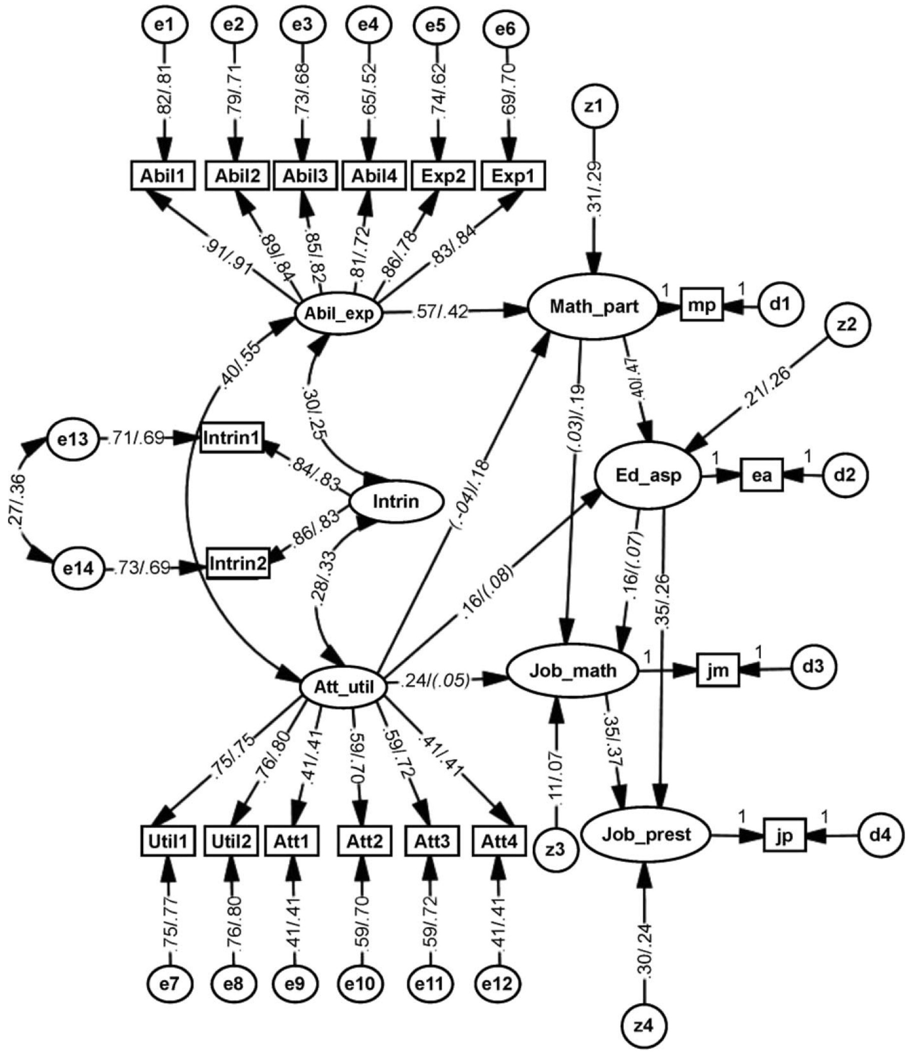

Figure 2. Structural path model diagram for the Canadian Adolescent Development and Educational Transitions study for female and male adolescents. Paired parameters indicate standardized estimates for female/male adolescents, and nonsignificant structural paths are indicated in italics in parentheses ($p > .05$). Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value; Math_Part = mp = high school math participation; Ed_Asp = ea = educational aspiration; Job_Math = jm = aspired career math-relatedness; Job_Prest = jp = aspired career prestige.

Discussion

This is the first study to compare the effects of expectancy-value motivation for mathematics on high school male and female adolescents' subsequent math- and nonmath-related dimensions of educational and occupational aspirations, based on longitudinal data across three separate countries. As predicted, motivational beliefs were predictive for male and female adolescents across countries. How do these findings advance our understanding of when and why female adolescents (and male adolescents) "leak" from the math pipeline, and what are the implications for nonmathematical outcomes? In general our hypotheses were supported, with illuminating particularities in each country.

As expected, gender differences in mathematical motivations favored male adolescents, where gender differences occurred (Hypothesis 1). In the Australian sample, male adolescents reported higher levels of intrinsic value than did female adolescents, whereas in both North American samples, male adolescents' perceived ability/success expectancy was higher than female adolescents'. It seems likely that the comparative testing regimes in North America focus adolescents' attention on their ability/success expectancy rather than their interests and values. Because ability/success expectancy and values are central to promoting male and female adolescents' later mathematical, and nonmathematical, educational and occupational aspirations, gender differences in these motivations are of high concern. Longitudinal studies have shown that gender differences in math-related ability beliefs and interests are in place from early on (Frenzel et al., 2010; Jacobs et al., 2002; Nagy et al., 2010; Watt, 2004), even among very young boys and

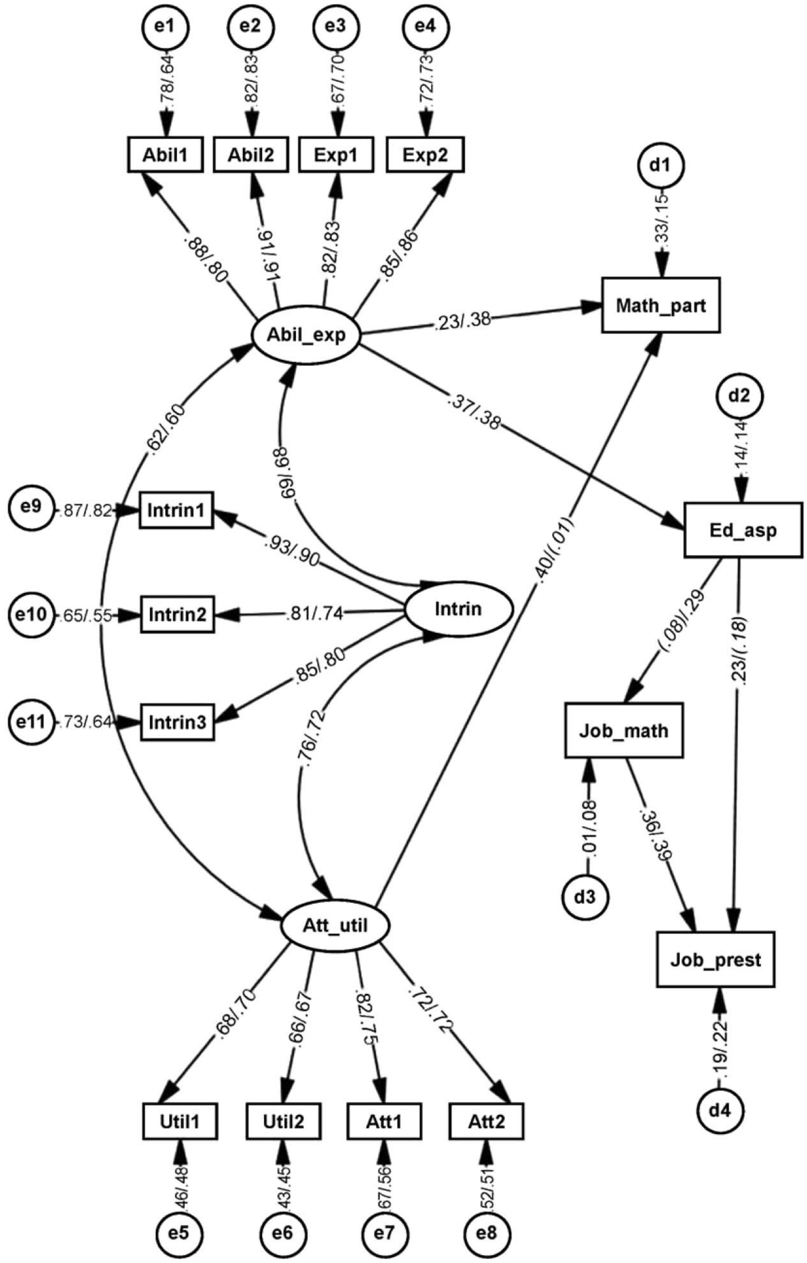

Figure 3. Structural path model diagram for the U.S. Childhood and Beyond Study for female and male adolescents. Paired parameters indicate standardized estimates for female/male adolescents, and nonsignificant structural paths are indicated in italics in parentheses ($p > .05$). Abil_Exp = ability/success expectancy; Intrin = intrinsic value; Att_Util = attainment/utility value; Math_Part = high school math participation; Ed_Asp = educational aspiration; Job_Math = aspired career math-relatedness; Job_Prest = aspired career prestige.

girls (Jacobs et al., 2002), and have implied that they need to be addressed from childhood.

Although gender differences appeared on only ability/success expectancy in the Canadian and U.S. samples, this is problematic, given it was a dominant motivational influence on subsequent educational and occupational outcomes. Therefore careful thought must be given to teacher/peer/media messages to female adolescents about their mathematical talent and ability. Because intrinsic value emerged as a key predictor for Australian participants, the fact that male adolescents showed higher interest in math than did female adolescents prompts the question, Are those factors that promote task interest equally fulfilled for female and male adolescents in Australian math classrooms? These factors include personal relevance, familiarity, novelty, activity level, and comprehensibility (Hidi & Baird, 1986). It could be that the math course selection structure in which students make a choice concerning degree of difficulty may be less motivating than in North America, where students select courses according to topic areas. The introduction of math "topic electives" may be well worth considering in Australia—a timely suggestion as the new national curriculum is being discussed. Efforts to heighten ability-related beliefs and math interest should promote female adolescents' (and male adolescents') participation in the math "pipeline," as well as enhance their aspirations toward higher education and, thereby, math-related and prestige career plans.

Gender differences in math participation were pronounced during high school only in the Australian sample (Hypothesis 2), presumably because the norms for college-bound students in the North American settings encourage students to take math courses beyond the amount mandated by the government. At the time of data collection in Sydney, Australia, no university degrees required the highest levels of math as prerequisite; this system thereby provided for a real choice and a more sensitive way of identifying that young girls and female adolescents were opting out of math at the first point at which they were given the opportunity to do so. Perhaps the early specialization afforded by this system may amplify gender differences in educational and occupational outcomes, an interesting proposition made earlier in the German context (Nagy et al., 2008). The Australian system, which does not "lock out" students from further study at the university based on their advanced high school enrollment as in the United States and Canada, does, however, provide for subsequent (re)entry into the math pipeline for students whose interest in math may be cultivated later.

Because of the structural differences in high school course selections, we had hypothesized that intrinsic value would play a greater role in Australian students' senior high math course choices (Hypothesis 3). Indeed, it predicted educational outcomes for only Australian female and male adolescents; there were no direct effects of intrinsic value in either the U.S. or Canadian sample. In contrast, direct effects of ability/success expectancy were identified in only the North American samples, likely related to a cultural emphasis on test regimes that focus attention on ability rather than interest. As a result, students in the different settings seemed to engage in different processes to make their enrollment decisions.

Attainment/utility, or "importance" value, played a greater role for female than male adolescents in their career choices (Hypothesis 4). In both the Australian and Canadian samples, it predicted math-related career plans for only female adolescents. Eccles and her colleagues have previously demonstrated that female adolescents are engaged by tasks they regard as socially meaningful and important (e.g., Eccles & Vida, 2003). Math is often taught in skills-based, abstract, and decontextualized ways and is therefore less likely to capture female adolescents' interest or the value they place on math. Since adolescents often have quite inaccurate ideas of what careers involve developed mathematical skills, information about the math required for different kinds of careers should enhance female adolescents' interest and valuation, when their preferred careers involve mathematics.

In general, attainment/utility values played an important role for female adolescents' educational aspirations and math-related career choices; attainment/utility was also relevant for Australian male adolescents. It could be that male adolescents' choices are more constrained than are those of female adolescents, given societal norms and parent expectations, so that their personal values play a smaller role. Among this demographic, parents of female adolescents have been reported to emphasize being happy and well adjusted as primary goals, in contrast to being successful for male adolescents (Willis, 1989), which may explain the stronger role of female adolescents' importance value. Because female adolescents were attracted by careers they considered important, and based on previous research regarding female adolescents' and women's career interests (e.g., Eccles & Vida, 2003), making explicit connections between math and its social uses should heighten the importance value that female adolescents attach to mathematical activities. This may be particularly relevant for careers involving information and communications technologies (ICTs), which have traditionally involved isolated work in front of a computer. As social networking (and technology in general) permeates all aspects of the labor force, it may serve to heighten female adolescents' interest in and valuing of ICT careers and reduce the digital gender divide. Continued attention to gendered math-related motivations promises avenues to shape long-term math engagement and career selection, for female and male adolescents.

We had wondered whether math-related motivational beliefs would additionally predict nonmathematical educational and occupational outcomes. This was the case for aspired level of education, although not directly for career prestige plans. In the Australian sample, intrinsic and attainment/utility values predicted educational aspirations; ability/success expectancy beliefs were predictive for the U.S. sample; in the Canadian sample, attainment/utility value predicted educational aspirations for only female adolescents. The centrality of values to Australian participants' choices, rather than the ability-related beliefs in the United States, with Canada somewhere in between, posed an intriguing contrast. According to the World Values Surveys (Inglehart & Welzel, n.d.), Australia—characterized by high subjective well-being and quality of life, in which people place a value on individual freedom, self-expression, and imagination—ranked third on the Survival/Self-Expression values dimension of the *Inglehart-Welzel Cultural Map of the World* (Inglehart & Welzel, 2005, p. 64); Canada was ranked sixth; and the United States eighth. In Australian culture, it may not be surprising to observe the important role interests and values play in students' future plans. It would be interesting to repeat this study in Australia in the future, where a test culture similar to that in North America appears to be emerging, to compare whether ability-related beliefs become more pronounced.

According to the pipeline metaphor, math course participation in senior high school should predict math-related career plans (Hypothesis 5). This occurred in the Australian and Canadian settings, where math course was further a pipeline to educational aspirations and to aspired careers. In contrast, math course participation had no subsequent effects in the United States sample, either direct or indirect, on any educational or occupational aspirations, representing a "broken pipeline." The seeming benefits of increasing requirements for students to undertake more math courses in high school appear not to translate into higher educational or occupational aspirations. This requires further investigation, as it may relate to the U.S. operationalization of math course participation, which counted all math courses undertaken during the final 2 years of high school and did not distinguish advanced from easier courses, and/or to the high missing data for U.S. math courses.

Our last hypothesis (Hypothesis 6) was that math-related career plans would relate to the prestige dimension of career plans and may relate more strongly for male than female adolescents; that is, that the leaky pipeline also has a glass ceiling. There was a moderate association between these two dimensions of career aspiration, something that has often been assumed but not directly tested. This supports the notion of math-related career fields as a gateway for occupational prestige, a core outcome of concern to researchers in regard to social gender equity. A positive finding was that there were no significant gender differences in this association, indicating that female adolescents who aspired to mathematically based careers were choosing careers of similar status to those chosen by male adolescents.

Limitations and Future Directions

Since these data were sourced from separate primary studies that were not designed for a comparative study, several limitations of this work do need to be mentioned. First, there were slight differences and/or omissions in expectancy-value measures for each country and different operationalizations of high school math participation, including high missing data for U.S. math courses. Another limitation derived from the younger Canadian cohort's having not yet selected their Grade 12 advanced math courses; our approach of averaging the elder cohort's advanced math enrollments through Grades 11 and 12 could underestimate advanced math participation that the younger cohort may yet undertake. Having identical measures would have enabled us to make stronger statements about the robustness of identified relationships among constructs across contexts. That said, we did utilize confirmatory factor analyses to confirm the expectancy-value constructs within each sample. The fact that they emerged consistently, despite item variations, suggests that the measures functioned robustly, providing a strong foundation for our findings.

Second, similar but not identical grades were sampled across the three studies (Australia: Grades 9 and 11; United States: Grades 10 and 12; Canada: Grades 9/10 and 11/12). We cannot rule out the possibility that we might have had different findings if the age ranges had been identical. A further limitation is that all the samples were highly homogeneous, with most participants of Anglo-European descent and from upper middle class backgrounds. Although this lack of diversity limits our ability to generalize to adolescents beyond this population, for the purposes of this study, homogeneity facilitated our ability to make comparisons. It is likely that the gender divide could be greater for individuals from less socioeconomically advantaged families, who face adversity such as poverty or racial discrimination in their everyday life, and that motivational processes could vary greatly across different kinds of cultural settings and schooling systems (see Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). It is paramount that future work in this area explores these questions with more diverse samples.

Although the study was longitudinal, the age range was quite limited. As we described in the introduction, leakage from the math pipeline can occur at multiple points through school, up until and after commencing employment. Indeed, the seeds for math disengagement are likely sown early in individuals' developmental trajectories, in the course of developing self-conceptions about their abilities and interests in different domains (e.g., Stage & Maple, 1996) and/or in response to particular kinds of work environments that may not accommodate women's frequently held dual family responsibilities (e.g., Frome, Alfeld, Eccles, & Barber, 2008). A final, related limitation is the reliance on educational and occupational aspirations as outcomes rather than actual levels of education attainment and eventual career of employment. Although aspirations have been shown to predict actual outcomes and are important variables for consideration, future work could incorporate a larger scope and follow participants over a longer period of time, across settings that afford different degrees of choices and affordances, to understand how these patterns play out during the transitions to postsecondary school and ultimately the labor force.

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