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ORIGINAL ARTICLE

Mathematics—a Critical Filter for STEM-Related Career Choices? A Longitudinal Examination among Australian and U.S. Adolescents

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Abstract Although women have made progress in entering scientific careers in biology, they remain underrepresented in mathematically intensive fields such as physics. We investigated whether gender differences in mathematics motivation and socialisers' perceptions impacted choices for diverse STEM careers of varying mathematical intensity. Drawing on expectancy-value theory, we tested structural equation models in which adolescents' preferred careers related to each of physics, biology, chemistry, and mathematics were predicted by prior mathematical performance, motivations, and mothers' perceptions. We explored potential differences in gendered processes of influence using multigroup models. Samples were 331 Australian adolescents followed from 9th to 11th grade in 1998 and 277 U.S. adolescents from 9th to 12th grade in 2009–10. In both samples female adolescents preferred biological careers more than males did; male adolescents preferred physics-related careers and also mathematical careers in the Australian sample. Mothers' perceptions were important to female and male adolescents' mathematics motivations; gendered motivations were more evident in the Australian sample. Mathematics interest played the strongest role in male adolescents' preferred careers, whereas actual or perceived mathematical achievements were most important for females, demonstrating the impacts of mathematical motivations on preferences for diverse STEM careers.

Keywords Gender · STEM · Mathematics · Critical filter · Career choice · Expectancy-value theory · High school

The winners of Google's first-ever science fair were announced in 2011. All three were young women (Miller 2011). In the last three years (2014–2016) *all* grand prize winners have been young women. The 2016 winning project involved a way to reduce drought with fruit, the 2015 project was aimed at fighting ebola, and the 2014 winners were three young women who collaborated on a project to address a bacteria that could fight world hunger (www.googlesciencefair.com). This snapshot captures much about current trends concerning gender and STEM (science, technology, engineering, and mathematics). Girls and young women are talented at, and interested in, science. They are most represented in biology and, as these examples illustrate, often they have a goal of helping people (Diekman et al. 2011; Eccles and Vida 2003).

It is imperative to disaggregate discussions of different fields of sciences rather than use an aggregated concept of STEM. The entry of women and men into STEM careers presents a mixed picture of gender similarities and gender differences (Hyde 2005). In 2014 in the United States, 53% of the doctoral degrees in biology went to women, 38% in chemistry, 20% in physics, and 22% in engineering (National Science Foundation 2016). In mathematics, women earned about 30% of doctoral degrees, and about 41% at the Bachelor's level (Hill et al. 2010). In Bachelor-level sciences

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women earned 19% of engineering degrees, 38% physical sciences, 58% biological and agricultural sciences, and 62% of social sciences and psychology (National Student Clearinghouse Research Center 2013). In Australia, outside the biological sciences, women's representation is even lower—with women earning 50% of the doctoral degrees in biology but 11% in chemical science and 5% in physical sciences (Dobson 2012). At the Bachelor level, 53% of degrees went to women in the natural and physical sciences, 13% in information technology, and 15% in engineering and related technologies (Australian Government Department of Education and Training 2014).

The dearth of women in advanced mathematics and associated fields (such as physics and engineering) has been attributed to numerous contributing factors including discrimination, societal gender inequality, women's purported lack of mathematical ability and spatial skills, cultural stereotyping of mathematics as masculine, gender differences in interests, and high-school academic preparation (Ceci and Williams 2011; Cheryan et al. 2015; Else-Quest et al. 2010; Hyde et al. 2008; Riegle-Crumb and King 2010; Sorby et al. 2013; Su et al. 2009; Wai et al. 2009). Mathematics was first identified as a critical filter by Lucy Sells in 1980 (see also Shapka et al. 2006). Researchers concerned with gender equity have focused on mathematics participation precisely because of its identified role in limiting access to high-status careers. Crucial motivational factors emphasised as impacting mathematical participation in expectancy-value theory (Eccles et al. 1983; Eccles 2005, 2009) are students' interest, perceived importance of mathematics, self-concept of own ability, actual performance, and key socialisers' perceptions. A wealth of literature has collectively established their role in predicting mathematics-related enrolments and career choices.

Our study asks whether mathematical expectancies and values could predict preferences for STEM-related careers *beyond* mathematics, that is, in fields of physics, chemistry, and biology. To test this idea, our study takes advantage of two longitudinal datasets—one from Australia and another from the United States—to examine mathematics-related influences on mathematical and scientific dimensions of students' subsequent career aspirations near the end of high school. We constructed and tested models capitalising on two study designs. In these models, earlier mathematics self-concepts and values, as well as prior mathematics performance and mothers' perceptions of the adolescents' mathematics ability, predicted career preferences in 11th (Australian study) or 12th grade (U.S. study). Although collected a decade apart (1998 and 2009–10, respectively), similar design and measures allow us to test the role of mathematics-related expectancy-value factors on dimensions of STEM aspirations among two separate longitudinal datasets from culturally similar settings. Testing the model with two samples from two cultures and somewhat different times allows us to assess the robustness of the model and whether the findings replicate across variations in setting and design.

High school is the crucial time when most students make choices whether to concentrate on STEM in the future (Maltese and Tai 2011). Course selections can foreclose future educational and career pathways (Watt 2006). In a U.S. decade-long study (Farmer et al. 1999), students' subsequent participation in science careers in 1990 was significantly predicted by high-school variables including academic performance and valuing mathematics and science from 1980, although predicting considerably more variance for men than for women. Occupational preference in senior high school plays a key role in the choice of students' college courses and adult occupational interests. As such, Riegle-Crumb and King (2010) have argued persuasively for the importance of the high-school years in determining disparities in STEM fields. Using data from the U.S. Educational Longitudinal Study (ELS) 2002, they demonstrated that much of the discrepancy in both gender and ethnic representation in college majors in the physical sciences and engineering was accounted for by differences in high-school course preparation.

According to the Eccles and colleagues' expectancy-value theory (EVT), a person chooses to take on a task—such as physics in high school or a mathematics major in college—if the person values the task and expects that s/he can succeed at it (Eccles 2005; Eccles et al. 1983). Different aspects of task value include importance and intrinsic values. Importance value refers to how useful or important the person perceives the task to be; intrinsic value resembles interest. Expectancy-value theory also outlines how values and ability expectancy beliefs (also referred to as mathematics self-concept) are shaped by prior performance in the domain and by socialisation experiences, such as mother's perceptions.

An abundance of research has demonstrated the crucial role of self-concept and values in adolescents' decisions to pursue challenging mathematics courses above and beyond measures of mathematical ability (Crombie et al. 2005; Meece et al. 1990; Updegraff et al. 1996; Watt et al. 2006; Wigfield 1993, 1994). For advanced mathematics enrolments in high school, Watt et al. (2006) found that intrinsic value was a predictor for Australian students, in contrast to self-concept in the U.S. sample, as well as importance value for female adolescents. Those authors interpreted these cultural differences in terms of the greater choice available to Australian students in upper-secondary school, which allowed them to follow their interests, whereas the highly test-driven culture in the United States may focus students' attention more on their ability.

Closely related research emphasises the importance of interest in promoting academic performance, course choices, and career paths (Hidi 1990; Hidi and Harackiewicz 2000;

Harackiewicz et al. 2016b). For example, interest in introductory college courses predicts subsequent course choices, even controlling for prior measures of ability and performance (Harackiewicz et al. 2000, 2002, 2008). Moreover, utility value and interest are linked; perceiving utility value in college course material predicted interest in the material assessed at the end of semester (Hulleman et al. 2008). Experimental manipulation of utility value increased interest in high-school and college STEM courses (Hulleman and Harackiewicz 2009; Harackiewicz et al. 2016a; Hulleman et al. 2010) and STEM course-taking in high school (Harackiewicz et al. 2012).

Gender Differences

Gender differences in mathematics-related self-concept and values are well-established. A cross-national meta-analysis of 2003 data from the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) studies found gender differences favouring boys and male adolescents for mathematics self-concept and self-efficacy (Else-Quest et al. 2010). Based on TIMSS data for mathematics self-concept, effect sizes for gender were $d = .19$ for Australia and .26 for the U.S. For mathematics self-efficacy assessed by PISA, effect sizes were $d = .37$ for Australia and .19 for the U.S. A major meta-analysis of research on vocational interests found a substantial gender difference in interest in engineering among North American adolescents and young adults ($d = 1.11$) (Su et al. 2009). More modest gender differences were found for interest in science ($d = .36$) and mathematics ($d = .34$) averaged across all ages tested. Stereotype threat theory and research may be relevant here (Steele 1997). Mathematics and physics continue to be culturally stereotyped as masculine domains (Steffens et al. 2010) in which boys and male adolescents may receive a stereotype boost (Shih et al. 2012; Walton and Cohen 2003); simply because they are male, they have higher expectations. At the same time, girls and female adolescents experience stereotype threat and may doubt whether they can succeed in these male-stereotyped fields. It is heartening that moderator analyses have indicated smaller gender differences in STEM interests among more recent cohorts (Su et al. 2009).

Gender differences in STEM perceptions are unlikely to be due to mathematical achievement differences. A meta-analysis of 242 studies of mathematics performance, published between 1990 and 2007 across numerous nations, showed no gender differences (Lindberg et al. 2010). In the United States, a meta-analysis of state assessments from the National Assessment of Educational Progress (NAEP) showed no gender differences in mathematics performance through the end of high school (Hyde et al. 2008). Using cross-national data from 14 to 16 year-olds tested by PISA and TIMSS, another meta-analysis found very small gender differences overall, but substantial variation across nations in the magnitude and direction of the gender differences (Else-Quest et al. 2010). For 14–16 year-olds' mathematical performance, gender effect sizes were: Australian $d = .15$ in TIMSS and .06 in PISA; U.S. $d = .06$ in TIMSS and .07 for PISA.

Motivations for Mathematical Career Choice

Researchers have increasingly begun to examine whether there are gender differences in the *processes* that link expectancies and values to career preferences. For example, is interest in mathematics equally important in predicting preferences for mathematics-related careers for male compared with female adolescents? A handful of previous studies has examined these possibilities and found evidence of gender differences in processes (Lazarides and Ittel 2013; Leaper et al. 2012; Robnett and Leaper 2013; Watt et al. 2012). Watt et al. (2012) examined whether mathematics expectancies and values predicted the mathematics-relatedness of careers to which students aspired in high school in the late 1990s, with samples from Australia, the United States, and Canada, using an occupational coding system for the extent to which aspired careers involved mathematics (none/any/average/high; from O*NET 98; U.S. Department of Labor Employment and Training Administration 1998).

Importance value predicted mathematical career plans for Australian and Canadian female adolescents, consistent with previous evidence that young women are engaged by tasks they regard as socially meaningful and important (Eccles and Vida 2003; see also Watt 2016). Stereotypic gender differences in educational and occupational outcomes occurred in the Australian sample. Male adolescents displayed higher mathematics intrinsic value in the Australian sample and higher mathematics self-concept in both North American samples. Self-concept was a key predictor in the North American samples, in contrast to intrinsic value among the Australian sample. Australian students' greater opportunities for choice in mathematics course-taking in high school should promote greater focus on interests (Watt et al. 2006; Watt et al. 2012). The centrality of values to Australian participants' future plans may not be surprising, given high cultural emphasis on individual freedom, self-expression, and imagination. For example, Australia is ranked third on the Survival/Self-expression values dimension of the Inglehart-Welzel Cultural Map of the World - a scatterplot locating countries according to dimensional scores from the World Values Survey (Inglehart and Welzel 2005, p. 64).

Societal values that emphasise self-expressive value systems have been proposed by others as an explanation for gender gaps in STEM careers among individuals in Western, middle class societies (Charles and Bradley 2009). These values are prominent in the United

States, Australia, and other post-industrial nations in which people seek to take courses and find an occupation that fits their interests and values. Charles and Bradley (2009) found that the gender gap in engineering was largest in postindustrial/postmaterialist nations, such as Finland, Germany, Switzerland, and Hong Kong. The gender gap in engineering was smaller in materialist nations with developing economies, such as Bulgaria, Colombia, Latvia, and Romania, where the goal is to acquire a stable job that pays well rather than to follow one's passions or interests. The emphasis on finding an interesting career matching one's abilities in the United States and Australia may contribute to gender gaps in fields such as physics and engineering—unless we can find ways to enhance girls' and young women's interest.

Measures of the mathematics-relatedness of adolescents' career intentions provide an important extension to understanding achievement-related choices beyond the high-school years. Although limited career opportunities as a consequence of limited participation in mathematics have been widely recognised, until fairly recently (see Watt 2006, 2008; Watt et al. 2012), there had been little study of relationships between these two aspects of mathematics participation in terms of empirical work establishing relationships between expectancies and values and mathematical career-relatedness. Those studies utilised the U.S. O*NET 98 database to operationalise mathematics career relatedness (U.S. Department of Labor Employment and Training Administration 1998; for full details see Watt 2002). That comprehensive database was based largely on data supplied by occupational analysts from sources such as the Dictionary of Occupational Titles (DOT) (see Osipow and Fitzgerald 1996, for an overview), refined and applied to the O*NET 98 content model in which the definition of career mathematics-relatedness was "using mathematics to solve problems", with classification codes ranging from none through any, average, and high.

Since O*NET 1998, the more recent O*NET 2011 model optimises power to detect individual differences by providing a continuous score (0–100) per STEM dimension, which captures the extent to which *knowledge* of each of mathematics, physics, chemistry, and biology is required for particular careers using updated information (National Center for O*NET Development 2011). The current study builds on the previous work by examining mathematics-related expectancy-value predictors of Australian and U.S. adolescents' aspired career—not only related to mathematics, but also to biology, chemistry, and physics. Antecedent measures of mathematical achievement and mothers' views were added as important background factors in the expectancy-value model.

The Role of Parents

Much research and theory on the underrepresentation of women in STEM fields seeks explanations within the individual, whether in terms of the individual's mathematical ability, interests, or course preparation. Long-term longitudinal research conducted by expectancy-value researchers within the Parent Socialisation Model demonstrates the important role of parents' beliefs in their children's later academic and occupational choices (Chhin et al. 2008; Davis-Kean 2005; Eccles et al. 1990, 1993a; Meece et al. 1982; Pomerantz and Dong 2006). Parents' general and child-specific beliefs shape children's future beliefs and choices (Chhin et al. 2008). Examples of parental beliefs have included gender-role attitudes, perceptions of the child's ability, and specific expectations for the prestige of the occupation the child will have. We utilised available measures of student-perceived (Australian study) or actual mothers' perception (U.S. study) of their child's mathematical ability to examine their role in the adolescents' developing mathematics self-concept, interest, and importance value—over and above the adolescent's prior mathematical achievement.

Perceived mothers' mathematics ability beliefs would more likely be predictive of adolescents' motivations than mothers' own-reported perceptions would be. Students' *interpretations* of environments have been argued to be more important than objective indexes because their perceptions of events amount to reality for them (Goodnow 1988). There is a sizeable body of data demonstrating that children's views on several issues are better predicted by their perceptions of parental positions than by the positions parents report for themselves (Goodnow 1988). Whether perceived or actual measures were available, however, the direction of influence is not completely clear. In a study investigating maternal influences on girls' and female adolescents' perceptions of mathematical ability, the reciprocal nature of parent-child influences over time has found the strength of influence over time to be greater from parent-to-child than from child-to-parent (Eccles et al. 1993a).

The Current Study

Recognising that gender differences in mathematics have been used as an explanation for the underrepresentation of women in mathematics-intensive careers, we sought to test whether, and the extent to which, mathematics motivations could explain aspirations towards different science-related careers—for female and male adolescents—over and above prior mathematical achievements and socialisers' perceptions. Motivational variables were mathematics self-concept and components of value (importance and interest). We expected that mathematics self-concept, interest, and importance value would all predict preferences for careers involving mathematics and physics, but it was an open question whether they would predict choices for the less mathematical sciences of biology and chemistry. We examined the possibility of gender-differentiated processes using the technique of multigroup structural equation modelling.

xThe two samples available to us were adolescents who completed 11th grade in 1998 (Australian sample) or 12th grade in 2009 or 2010 (U.S. sample). The design included two points in time, with data from 9th and 11th grades (Australian) and 9th and 12th grades (U.S.), thus making it possible to test predictions over time. We investigated gender differences in mathematics self-concept, interest, importance value, and aspired careers related to mathematics, physics, chemistry, and biology. Mothers' perceptions were included as a predictor of adolescents' expectancies and values, and students' prior mathematics achievement and mothers' education level were included as controls. We did not expect to find gender differences in mathematical performance, but instead we predicted that gender differences would favour young men for self-concepts, values, and STEM-related career intentions—except for biology, where higher values for female adolescents were anticipated. Based on the preceding review, gender differences were expected more among the earlier Australian than among the contemporary U.S. sample. Finally, values were expected to play a greater role in predicting career choices in Australia than in the United States.

Study 1: Australia

Method

Participants

Australian data come from the Study of Transitions and Education Pathways (STEPS 2016; Watt 2004) which involved three government secondary coeducational schools in metropolitan Sydney that enrolled students of upper middle-class socioeconomic status. The eldest STEPS cohort, who completed surveys through 1996–1998 at the start of each of grades 9 and 11, is included in the present study. Those present at both points in time were identified (N = 358 of the 459 students initially present at grade 9), of whom 27 students who wrote that they were undecided on their career choice were excluded. Thus the final sample included 331 students (146, 44%, young women and 185, 56%, young men). At grade 9, the average age for these 331 students was 14.41 years (SD = .53); 73.1 % (n = 242) nominated English as their home language (other home language groupings were 71 (21.6%) Asian, 7 (2.0%) European, 10 (3.1%) Middle Eastern, and 1 (.2%) South American).

Measures

At Time 1 (grade 9) students reported their mothers' highest level of education on an ordinal scale from 1 (partly completed high school), 2 (completed high school), 3 (technical college), to 4 (university degree). At Time 1 students also responded to two items about their mothers' perceptions of students' own mathematical abilities: "How talented does your mother think you are at maths?" and "How well does your mother expect you to do at maths at school?" As a measure of prior mathematics performance, at grade 9 students were asked to report as a percentage, "What mark did you get for your final Year 8 maths result?"

xMathematics-related motivations were measured in grade 9 using Eccles and colleagues' expectancy-value measures (Eccles 2005; Wigfield and Eccles 2000), with grammatical and contextualising modifications for the Australian sample (Watt 2004). These measures focused on perceived ability/success expectancy (self-concept), intrinsic value (interest), and attainment/utility value (importance). Each item was rated on a 7-point scale from 1 (*not at all*) to 7 (*very*). All items and Cronbach's alpha measures of internal consistency are presented in Table 1.

At Time 2 in grade 11, Australian students were asked: "What career are you mainly considering for your future?" Each student's career was then coded for the amount of mathematics and science knowledge (biology, chemistry, and physics) that was required for that occupation, using O*NET 2011 (National Center for O*NET Development 2011), a project of the U.S. Department of Labor. This coding provided a quantification of the STEM knowledge required for a particular occupation on a scale from 0 to 100. For example, for biostatisticians, mathematics = 95, biology = 49, chemistry = 12, and physics = 10. Scores in the O*NET database are based on data from workers and occupation experts. O*NET has the substantial advantage of yielding a continuous score for each dimension rather than a dichotomous variable (e.g., plans to be a physicist or not). If students listed more than one occupation, the one that they listed first was coded. Occupational data could be coded for 286 of the 331 participants.

Data Analyses

Analyses were conducted within the multiple-group mean and covariance structures framework using Amos 21 (emulisrel6 option selected) to include mean-level information in addition to the covariance matrix. All measurements were specified as

Table 1 Unconstrained CFA completely standardised factor loadings (LX) and Cronbach alpha reliabilities

Construct	Item	Item stem	LX males	LX females
Australia				
Math self-concept (α = .832; grade 9)				
	Abil1:	Compared with other students in your class, how talented do you consider yourself to be at maths?	.60	.60
	Abil2:	How talented do you think you are at maths?	.70	.78
	Exp1:	How well do you expect to do in your next maths test?	.86	.87
	Exp2:	How well do you expect to do in school maths tasks this term?	.84	.85
	Exp3:	How well do you think you will do in your school maths exam this year?	.76	.92
Math interest (α = .941; grade 9)				
	Intrin1:	How much do you like maths, compared with your other subjects at school?	.91	.85
	Intrin2:	How interesting do you find maths?	.92	.93
	Intrin3:	How enjoyable do you find maths, compared with your other school subjects?	.94	.92
Math Importance (α = .881; grade 9)				
	Att1:	To what extent will you need maths in your future work/career?	.74	.77
	Att2:	How important is doing well in maths to you?	.69	.66
	Util1:	How useful do you believe maths is?	.82	.92
	Util2:	How useful do you think maths is in the everyday world?	.91	.77
	Util3:	How useful do you think mathematical skills are in the workplace?	.87	.82
Mother's perception[a] (α = .707; grade 9)				
	Mq2:	How talented does your mother think you are at maths?	.69	.74
	Mq4:	How well does your mother expect you to do at maths in high school?	.80	.73
Math score[b]		What mark did you get for your final Year 8 maths result? (%)	1.00	1.00
Mother's education		What level of education does your mother have? (1 = part high school; 2 = high school; 3 = technical college; 4 = university)	1.00	1.00
What career are you mainly considering for your future? (grade 11)				
Math[b]		mathematics O*NET score /100	1.00	1.00
Physics[b]		physics O*NET score /100	1.00	1.00
Chemistry[b]		chemistry O*NET score /100	1.00	1.00
Biology[b]		biology O*NET score /100	1.00	1.00
United States				
Math Self-concept (α = .882; grade 9)				
	Abil1:	How good are you at math?	.95	.95
	Abil2:	If you were to rank all of the students in your most recent math class from the worst to the best, where would you put yourself?	.82	.84
	Abil3:	Compared to most of your other school subjects, how good are you at math?	.80	.81
Math interest[b] (grade 9)		How interesting is math to you?	1.00	1.00
Math importance (α = .811; grade 9)				
	Util1:	How important is it that you learn math?	.89	.91
	Util2:	How important is math to your future?	.80	.73
Mother's perception (α = .933; grade 7)				
	Mq1:	How good is your child at math?	.94	.92
	Mq2:	How good is your child at math, compared to other kids?	.93	.92
	Mq3:	How well did your child do in math this year?	.86	.81
	Mq4:	How much natural talent does your child have in math?	.90	.85
Math score[b] (grade 10)		WKCE math scores	1.00	1.00
Mother's ed. [b]		How many years of education do you have?	1.00	1.00
What job or career would you like when you're 30 years old? (grade 12)				
Math[b]		Mathematics O*NET score	1.00	1.00
Physics[b]		Physics O*NET score	1.00	1.00
Chemistry[b]		Chemistry O*NET score	1.00	1.00
Biology[b]		Biology O*NET score	1.00	1.00

Not presented are the measurement errors (TD); latent intercorrelations shown in Table 5

[a] items constrained to load equally for two-item subscales

[b] Alphas are not applicable for single-item indicators

interval data, except for mother's level of education which was ordinal. Because popular approaches to missing data, such as mean substitution as well as listwise and pairwise deletion, can bias results (Allison 2001), Full Information Maximum Likelihood (FIML; Arbuckle 1996) estimation was used to include all observed data.

Measurement Models

xMeasurement equivalence indicates that constructs are generaliseable to different 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. Strong factorial invariance (Little 1997; Meredith 1993), or scalar invariance, implies that constructs are fundamentally the same across groups and consequently directly comparable. This is tenable when sequential introduction of equality constraints for factors' loading and intercept parameters does not produce substantial change in model fit. The sequence of analyses involves: (a) a combined multiple-group model with no cross-group equality constraints imposed on latent constructs for young men and young women (Model 1), (b) the addition of the constraint that loadings are invariant across samples (Model 2), and (c) the assumption that intercepts are equivalent (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 recommended inspection of changes in practical fit indices—initially with a margin of .05 (Little 1997) and later a more stringent margin of .01 (Little 2013)—indicating acceptable model similarity to proceed with the introduced constraints. For factors that were measured by a single indicator, those item loadings were fixed to unity and error variances to zero; uniquenesses for the four STEM career preference outcomes were permitted to freely covary.

Gender Differences

Gender differences in STEM career preferences and mathematics score were compared using MANOVA. For latent constructs measured by multiple indicators, latent mean gender differences were estimated. Young men were set as the reference group, such that the freely estimated latent means for young women produced the latent effect sizes corrected for measurement error.

Gendered Processes

Multigroup structural equation models (SEMs) examined the processes by which prior grade 8 achievement, grade 9 motivational factors, mothers' perceptions, and mothers' education influenced male versus female adolescents' STEM career preferences by grade 11. Structural paths that were non-significant for both female and male adolescents ($p > .05$) were sequentially deleted to achieve the final model. To identify where different gender processes occurred, structural paths were sequentially constrained to be equal; 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 significantly different processes for female and male adolescents.

Results

Measurement Models

Among the Australian STEPS sample, initial unconstrained multigroup confirmatory factor analysis (Model 1) examined construct validity for male and female adolescents, with items specified as indicators only for their respective factors, error variances and factor correlations freely estimated, and no error covariances permitted. Factor loadings were all statistically significant and are presented in Table 1. Model fits for sequential constrained Models 1 through 3 are shown in Table 2. In each, fit statistics were acceptable, and although the change in Chi-square was statistically significant, showed small changes in practical fit indices across sequential models, well below the .05 margin referred to by Little (1997) and all but one ($p = .012$) below the stricter .01 margin (Little 2013). The condition of scalar invariance was therefore met, indicating that quantitative comparisons of factor scores could be meaningfully undertaken across gender groups.

Gender Differences

Despite similar reported prior mathematical achievement, $F(1, 217) = .034$, $p = .853$, $\eta_p^2 = .000$, male adolescents preferred careers that were related to mathematics and physics significantly more than did female adolescents, $F(1, 217) = 16.018$, $p < .001$, $\eta_p^2 = .069$, for mathematics; $F(1, 217) = 17.008$, $p < .001$, $\eta_p^2 = .073$, for physics. Female adolescents significantly preferred careers related to biology, $F(1, 217) = 4.773$, $p = .030$, $\eta_p^2 = .022$; there was no gender difference for chemistry-related careers, $F(1, 217) = 1.901$, $p = .169$, $\eta_p^2 = .009$. Careers related to mathematics were preferred more than careers in physics, chemistry or biology (see Table 3 for descriptive statistics). Female adolescents had significantly lower interest than male adolescents did in mathematics, lower self-concept, and considered their mothers to believe them to be less talented (see Table 4); male and female adolescents perceived similar mathematics importance.

Motivational Processes

The final structural equation model, including scalar invariance constraints for female and male adolescents, exhibited satisfactory model fit across a range of frequently emphasised indices ($\chi^2 = 599.171$ df = 369, RMSEA = .044, TLI = .927, CFI = .942; see Fig. 1). xFor male adolescents, grade 11 mathematics-, physics- and chemistry-related careers were directly predicted by grade 9 mathematics interest; biology-related careers, by grade 9 mathematics importance. For female

Table 2 Fit statistics for sequential constrained models

Steps	χ^2	df	RMSEA	CFI	TLI	$\Delta\chi^2$(df)	ΔCFI	ΔTLI
Australia								
Model 1: Freely estimated	470.34	302	.041	.957	.935			
Model 2: Loadings invariant	493.56	312	.042	.954	.932	23.22(10)*	.003	.003
Model 3: Scalar invariance	550.35	327	.046	.943	.920	56.79(15)*	.011	.012
United States								
Model 1: Freely estimated	218.39	138	.065	.982	.969			
Model 2: Loadings invariant	221.64	144	.062	.983	.971	3.25(6)	.003	.002
Model 3: Scalar invariance	253.24	161	.064	.980	.970	31.60(17)*	.003	.001

* $p < .05$

adolescents, all four career STEM dimensions were predicted by grade 9 mathematics self-concept. Interest and self-concept were strongly correlated (ϕs = .70 for male, .59 for female adolescents), as were interest and importance (ϕs = .49 for male, .44 for female adolescents). Self-concept and importance correlated only for male adolescents (ϕ = .47). Grade 9 student-reported mother perceptions correlated highly with students' mathematics interest (ϕs = .52 for male, .63 for female adolescents), self-concept (ϕs = .70 for male, .84 for female adolescents), and importance (ϕs = .41 for male, .30 for female adolescents). Grade 8 mathematics achievement was highly correlated with mothers' perceptions for female adolescents (ϕ = .78), less so for male (ϕ = .52). Achievement was moderately related to interest (ϕs = .48 for male and female adolescents), self-concept (ϕs = .46 for male, .70 for female adolescents), and importance for male adolescents (ϕ = .23). Latent correlations between all constructs are shown in Table 5. Parameter estimates for the SEM are presented in Table 6.

Significant gender moderation occurred between each of prior mathematics achievement with self-concept, and achievement with mothers' perceptions. Female adolescents' mathematics self-concept was significantly and substantially associated more with their prior achievement than was the case for male adolescents; reported mothers' perceptions concerning their daughters' mathematical abilities were significantly and substantially more closely tied to daughters' achievement in mathematics than to sons'.

Study 2: United States

Method

Participants

Participants were 298 adolescents (158, 53%, female adolescents) who participated in the longitudinal Wisconsin Study of

Table 3 Descriptive statistics by gender for observed study variables, Australia and U.S.

Variables	Australia			United States		
	Males *M (SD)*	Females *M (SD)*	*d*[a]	Males *M (SD)*	Females *M (SD)*	*d*[a]
Career preferences:						
Math	53.74 (19.15)	43.45 (17.89)	.56*	54.46 (18.08)	51.58 (17.06)	.16
Physics	24.51 (22.13)	14.41 (15.75)	.54*	29.40 (21.81)	19.68 (18.62)	.48*
Chemistry	21.50 (19.81)	18.48 (20.96)	.15	29.88 (22.65)	31.43 (22.96)	-.07
Biology	16.41 (23.55)	24.84 (29.62)	-.32*	27.31 (28.47)	40.11 (30.04)	-.44*
Previous math performance	75.27 (16.33)	75.82 (15.21)	-.03	599.97 (37.11)	598.34 (36.02)	.04
Math interest [b]				3.79 (1.79)	3.79 (1.88)	.00

The mathematics and science knowledge requirements of preferred careers are scored on a scale from 0 to 100. Previous mathematical performance is reported as a percentage for Australian data and as a standardised test score for U.S. data

[a] *d* is the effect size for the gender difference, equal to the mean for males minus the mean for females divided by the pooled within-groups SD

[b] Measured by a single item for U.S. sample and by multiple item indicators for Australian sample. Values for Australia are therefore shown in Table 4, which reports values for latent variables

*$p < .05$

Table 4 Gender differences in mathematics motivation variables: latent means (KA), item intercepts (TX) and loadings (LX)

Variables	KA (females)	Variance	*p* (C.R.)	Item	TX	LX
Australia						
Mom perception	-.370	.560	<.001	[a]mq2_9	5.358	1.000
				[a]mq4_9	6.042	1.000
Self-concept	-.611	.754	<.001	Abil1	4.810	.765
				[a]Abil2	5.025	1.000
				Exp1	5.498	1.080
				Exp2	5.470	.990
				Exp3	5.452	1.035
Interest	-.715	2.753	<.001	Intrin1	4.262	.968
				Intrin2	4.514	1.008
				[a]Intrin3	4.196	1.000
Importance	-.008	1.113	.948	Att1	5.342	1.141
				Att2	5.866	.752
				Util1	5.826	1.111
				Util2	5.827	1.079
				[a]Util3	5.851	1.000
United States						
Mom perception	-.090	1.338	.723	[a]Mq1	5.671	1.000
				Mq2	5.336	1.020
				Mq3	5.842	1.002
				Mq4	5.195	1.071
Self-concept	.093	1.551	.720	[a]Abil1	5.167	1.000
				Abil2	5.072	1.007
				Abil3	4.575	.842
Importance	.283	2.709	.322	[a]Util1	5.512	1.000
				Util2	5.728	1.210

Parameter estimates are presented in unstandardised form; latent means (KA) are relative to the male adolescents as reference group in the original metric; item loadings and intercepts were constrained to be equal across gender groups

[a] Indicators of each construct were fixed to 1 to establish the factor metric. Not included are the measurement errors

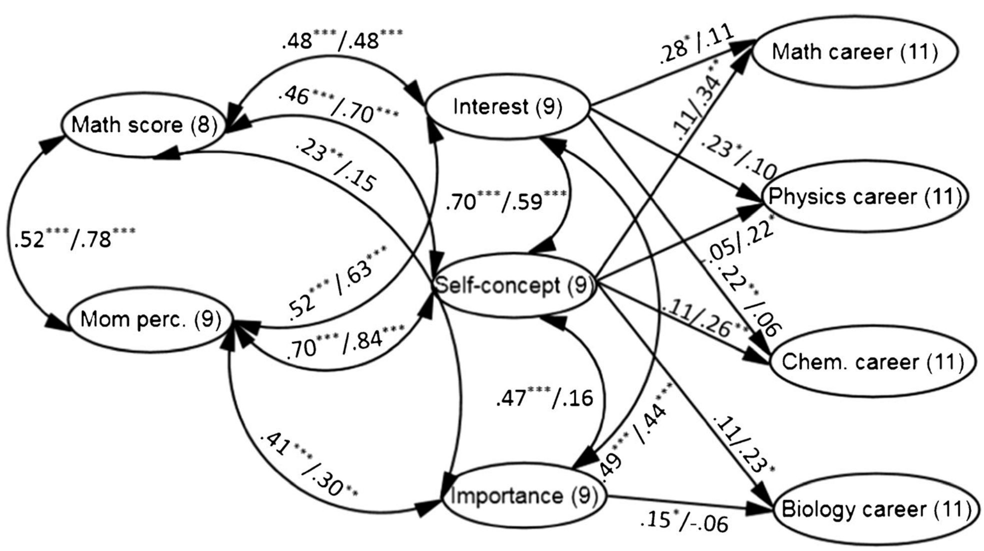

Fig. 1 Structural diagram for Australian STEPS male and female adolescents. Mom perc = Moms' perceptions; Chem. career = Chemistry career. Paired parameters indicate standardised structural paths for male/female adolescents for scalar invariant SEM; grade measured is presented in brackets per construct. Not represented are measurement errors, uniquenesses, intercepts or variances (refer to Table 6). All single-item indicators specified to have loadings of 1 and 0 measurement error. * $p < .05$. ** $p < .01$. *** $p < .001$

Table 5 Latent correlations between constructs for male / female adolescents

Constructs	Mom ed.	Mom perc.	Math score	Self-concept	Interest	Importance	Math career	Physics career	Chemistry career	Biology career
Australia										
Mom ed.	-	-.02/.17	-.04/.03	-.01 /.02	-.08/-.01	.01/.04	-.13/-.14	.05/.03	.21*/.03	.25**/.04
Mom perc.	-.02/.16	-	.52** /.78**	.71**/.84**	.52**/.63**	.41**/.31**	.24*/.40**	.07/.25*	.13/.26*	.14/.23*
Math score	.04/.02	.51**/.77**	-	.46**/.70**	.48** /.48**	.24**/.15	.25* /.38**	.10/.24*	.02/.25*	.07/.21*
Self-concept	-.01 /.01	.71** /.82**	.45**/.68**	-	.70**/.59**	.47** /.16	.30**/.39**	.08/.28**	.05/.30**	.18*/.24*
Interest	-.08/-.02	.50** /.60**	.47**/.44**	.69**/.54**	-	.49**/.45	.36**/.31**	.20*/.24*	.19*/.22*	.20*/.16
Importance	.02/.04	.41**/.33**	.23**/.16	.47**/.19*	.49** /.47**	-	.18*/.14	-.02/.06	.03/.14	.18*/.17
Math career	-.13/-.14	.23* /.38**	.24** /.37**	.28**/.38**	.34**/.28**	.18*/.15	-	.62**/.56**	.45**/.54**	.29**/.37**
Physics career	.05/.03	.06/.23*	.10/.22*	.07/.26**	.19*/.22*	-.03/.07	.62**/.56**	-	.73**/.74**	.46**/.54**
Chem. career	.21*/.03	.12/.24*	.01 /.23*	.03/.27**	.19*/.19*	.03/.15	.45**/.53**	.73**/.73**	-	.77**/.88**
Bio. career	.25**/.04	.13/.21	.07/.20*	.17*/.23*	.20*/.15	.18*/.17	.29** /.37**	.46**/.54**	.77**/.88**	-
United States										
Mom ed.	-	.11/.14	.19/.28**	.16/.15	.08/.12	.13/.08	.06 /.06	.11/.08	.15/-.03	.20* /.08
Mom perc.	.11/.14	-	.43**/.42**	.38**/.18*	.23** /.20**	.25**/.25**	.06 /.11	.05/.15	.01/.14	.00/.15
Math score	.19/.28**	.42** /.42**	-	.34** /.27**	.36**/.26**	.21*/.18*	.17 /.11	.02/.28**	.07/.10	.15/.04
Self-concept	.16/.15	.37**/.18*	.34**/.28**	-	.80**/.71**	.88**/.86**	.28**/-.05	.09/.08	.07/-.12	.00/-.10
Interest	.08/.12	.23**/.19	.36**/.25**	.80**/.70**	-	.81**/.68**	.32**/-.02	.11/.05	.09/-.12	.05/-.09
Importance	.13/.08	.26**/.24**	.21**/.19*	.88**/.86**	.81**/.68**	-	.26**/-.09	.10 /.02	.03/-.15	-.03 /-.14
Math career	.06/.06	.05 /.11	.17 /.11	.28**/-.05	.32**/-.02	.26**/-.08	-	.63**/.55**	.45**/.53**	.08 /.43**
Physics career	.11/.08	.05/.15	.02 /.28**	.10/.08	.11/.05	.09/.02	.63** /.55**	-	.54**/.53**	.09/.33**
Chem. career	.15/-.03	.01/.14	.07 /.10	.07/-.13	.09/-.12	.03/-.15	.45**/.53**	.54**/.53**	-	.69** /.84**
Bio. Career	.21*/.08	.00/.15	.15 /.04	.00/-.11	.05/-.08	-.03/-.14	.09/.43**	.09 /.33**	.69**/.83**	-

Mom perc mom's perceptions, *Mom ed* mom's education. Correlations below diagonal from unconstrained CFA; above diagonal from scalar invariant CFA

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

Table 6 Scalar invariant SEM: Item loadings (LX/Y in original metric and standardised), intercepts (TX/Y), and correlated uniquenesses (Z)

Construct	Item	TX/Y	LX/Y	Standardised LX/Y:		Correlated uniquenesses (Males/Females $p < .01$)		
				Males / Females		Math	Physics	Chem.
Australia								
Self-concept	Abil1	4.65	.76	.57	.67			
	Abil2	4.82	1.00	.72	.80			
	Exp1	5.27	1.08	.85	.90			
	Exp2	5.26	.99	.83	.88			
	Exp3	5.23	1.04	.81	.91			
Interest	Intrin1	3.94	.97	.91	.87			
	Intrin2	4.17	1.01	.93	.92			
	Intrin3	3.86	1.00	.94	.93			
Importance	Att1	5.30	1.15	.76	.74			
	Att2	5.84	.76	.68	.67			
	Util1	5.79	1.12	.84	.90			
	Util2	5.78	1.08	.89	.81			
	Util3	5.81	1.00	.86	.82			
Mom. perc	mq2_9	5.24	1.00	.69	.75			
	mq4_9	5.92	1.00	.80	.75			
Math score		72.96	1.00	1.00	1.00			
Mom ed.		2.79	1.00	1.00	1.00			
Math career		52.05	1.00	1.00	1.00			
Physics career		23.87	1.00	1.00	1.00	.24 / .51	--	
Chemistry career		21.11	1.00	1.00	1.00	.43 / .48	.72 / .71	--
Biology career		15.47	1.00	1.00	1.00	.24 / .31	.46 / .51	.78 / .88
United States								
Mom perc.	Mq1	5.78	1.00	.94	.92			
	Mq2	5.35	1.02	.93	.92			
	Mq3	5.65	1.00	.86	.81			
	Mq4	5.48	1.05	.90	.85			
Self-concept	Abil1	5.22	1.00	.95	.95			
	Abil2	5.05	.84	.82	.84			
	Abil3	4.52	.99	.80	.81			
Importance	Util1	5.60	1.00	.79	.73			
	Util2	5.73	1.14	.89	.91			
Interest		3.76	1.00	1.00	1.00			
Math score		598.92	1.00	1.00	1.00			
Mom ed.		15.25	1.00	1.00	1.00			
Math career		54.57	1.00	1.00	1.00			
Physics career		29.67	1.00	1.00	1.00	.66 / .55	--	
Chemistry career		29.62	1.00	1.00	1.00	.43 / .53	.52/ .54	--
Biology career		27.31	1.00	1.00	1.00	.04[a] / .43	.07[a] / .34	.69 / .83

Mom perc mom's perceptions, *Mom ed* Mom's education. Not presented are the measurement errors (TD/TE), variances/covariances; latent intercorrelations (Φ) shown in Table 5; structural paths (γ) in Figs. 1 and 2

[a] not significant ($p > .05$)

Families and Work (Hyde et al. 1995; the sample excludes families who were part of an intervention group; Harackiewicz et al. 2012). The average age of students was 15.50 years (*SD* = .32) in 9th grade in 2006–2007 and 18.51 years (*SD* = .33) in 12th grade in 2009–2010. Those present at both points in time were included (reduced $N = 277$; 153, 55%, female adolescents). Ethnic distribution was 90.4% White adolescents, 1.0% Black, and 8.6% biracial or multiracial, characteristic of the state of Wisconsin where 90% of the population is White (U.S. Census Bureau 2006). Participants attended 144 different high schools across Wisconsin and 12 other states. Roughly half the sample completed high school in 2009; the other half in 2010. Mothers' total years of education ranged from 10 to 20 ($M = 15.31$ years, $SD = 2.04$), where high school graduation or GED (passing the General Educational Development test) counted as 12 years.

Measures

At grade 9 (Time 1), as in Study 1, youth completed items developed by Eccles and Wigfield (1995). Mathematics self-concept was measured with three items ("How good at math are you?"; "If you were to rank all of the students in your most recent math class from the worst to best, where would you put yourself?"; "Compared to most of your other school subjects, how good are you at math?"); interest was tapped by a single item ("How interesting is math to you?"); and importance by two items ("How important is it that you learn math?"; "How important is math in your future?"), rated on 7-point scales from 1 (*not at all*) to 7 (*very*).

The study was embedded within a larger ongoing longitudinal study. At an earlier wave of data collection in grade 7, mothers had rated their perceptions of their child's mathematical ability using four items from the Eccles scales (Eccles and Wigfield 1995; Eccles et al. 1983) rated on 5-point scales that were also included ("How good is your child at math?"; How good is your child at math, compared to other kids?"; "How well did your child do in math this year?"; "How much natural talent does your child have in math?").

School transcripts were obtained for 242 of the participants. Standardised mathematics test scores were taken from the Wisconsin Knowledge and Concepts Exam (WKCE) administered to all Wisconsin students in public schools in October of 10th grade. Participants' WKCE scores ranged from 473 to 723 ($M = 599.06$, $SD = 36.43$). These scores were missing for students who had moved to other states and those who attended private schools or were home schooled. Finally, at 12th grade (Time 2), students were asked, "What job or career would you like to have when you're 30 years old?" Responses were coded using O*NET 2011 as described in Study 1 such that a continuous score provided a quantification of the STEM knowledge required for nominated occupations on a scale from 0 to 100.

Results

Measurement Model

The same method used to determine scalar invariance was repeated with the U.S. sample. As in Study 1, all factor loadings for the unconstrained model were statistically significant and the model indicated adequate fit (see Table 1). Model fit for the sequentially constrained models supported scalar invariance (see Table 2).

Gender Differences

A MANOVA examined gender differences in mothers' education, adolescents' mathematics interest, standardised test scores, and occupational aspirations. There was a significant multivariate effect of gender, $F(7, 185) = 4.127$, $p < .001$, $\eta_p^2 = .135$. This was due to significant differences on biology-related career aspirations, which were higher for female adolescents, $F(1, 191) = 7.014$, $p = .009$, $\eta_p^2 = .035$, and physics-related careers, which were higher for male adolescents, $F(1, 191) = 13.426$, $p < .001$, $\eta_p^2 = .066$; both effect sizes were moderate (see Table 3). Other variables were similar for male and female adolescents, including the standardised mathematics test ($d = .04$). As in Study 1, latent means were set to zero for male adolescents for constructs measured by multiple item indicators such that latent means represent female adolescents' difference relative to males. No significant gender differences were found for mathematics interest, self-concept, or importance (see Table 4).

Motivational Processes

The final structural equation model, shown in Fig. 2 (including scalar invariance constraints), exhibited satisfactory fit ($\chi^2 = 333.56$, df = 201, RMSEA = .049, TLI = .923, CFI = .943; see Table 2). For male adolescents only, 9th grade mathematics interest predicted 12th grade career aspirations related to mathematics. Physics career aspirations were predicted by importance value for male, and mathematics achievement for female adolescents. Mathematics interest and self-concept were moderately correlated (ϕs = .52 for male, .43 for female adolescents), as were interest and importance value (ϕs = .45 for male, .24 for female adolescents). Students with higher self-concept had higher scores on the mathematics standardised test (ϕs = .56 for male, .41 for female adolescents); test score was correlated with mathematics interest (ϕs = .37 for male, .22 for female adolescents). Mothers' perceptions correlated with students' mathematics interest (ϕs = .27 for male, .21 for female adolescents), self-concept (ϕs = .63 for male, .33 for female adolescents), and standardised test scores (ϕs = .64 for male, .58 for female adolescents). There were no significant gender moderated paths. Latent correlations among all constructs are shown in Table 5; parameter estimates for the SEM are in Table 6.

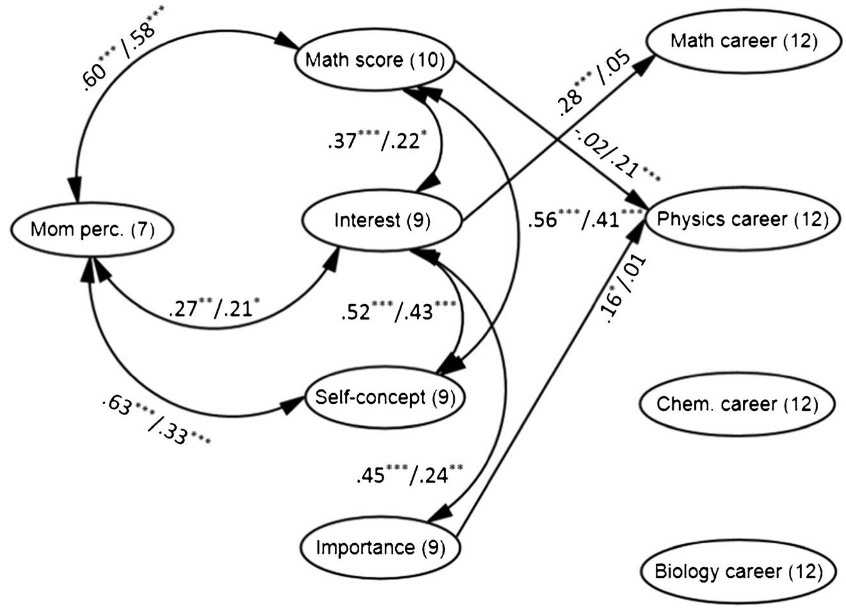

Fig. 2 Structural diagram for WSFW United States male and female adolescents. Mom perc = Moms' perceptions; Chem. career = Chemistry career. Paired parameters indicate standardised structural paths for male/female adolescents for scalar invariant SEM; grade measured is presented in brackets for each construct. Not represented are measurement errors, uniquenesses, intercepts or variances (refer to Table 6). All single-item indicators were specified to have loadings of 1 and 0 measurement error. * $p < .05$. ** $p < .01$. *** $p < .001$

Discussion

Our study sought to understand whether mathematics-related motivational factors predicted the mathematics, biology, chemistry, and physics requirements of careers indicated by female and male adolescents at the end of high school among samples from two similar settings, albeit collected a decade apart and with slightly different methods. Did mathematics act as a critical filter across diverse STEM career aspirations? Mathematics-related perceptions and achievement had implications for each examined STEM domain in the Australian sample and for half the STEM domains in the U.S. sample, with different emphases for female and male adolescents. To our knowledge, this is the first study to disaggregate high-school students' preferred future occupations for the knowledge required for not only mathematics, but also biology, chemistry, and physics. This allowed us to examine gender differences across different STEM dimensions of career plans; whether and how they were predicted by mathematics self-concepts, values, achievement background and mother perceptions; and whether predictions were moderated by students' gender.

Findings across the two samples showed many similarities. Consistent with the patterns noted in the introduction, male adolescents' aspired careers required more knowledge of physics than did females'—in both samples. In contrast, female adolescents were more likely than were male, to prefer careers that involved knowledge of biology. In Australia, male adolescents' preferred careers also required more mathematical knowledge than did females'; in the U.S. sample, the gender difference was not significant (consistent with findings for the Eccles et al. U.S. CAB sample collected a decade earlier, reported in Watt et al. 2012). Female adolescents' lesser preference for physics-related careers (and mathematics-related careers in the Australian sample) did not lie in deficits in mathematical performance. Gender similarities occurred for mathematical performance in both samples, consistent with the well-sampled TIMSS and PISA studies of both nations (see Else-Quest et al. 2010). Despite this performance similarity, male adolescents in the Australian sample had higher mathematics self-concept and interest than female adolescents did. For chemistry, there was no significant difference in career-related intentions in either sample, consistent with national patterns in the United States (National Student Clearinghouse Research Center 2013) and Australia (Dobson 2012).

Limitations and Future Research Implications

The two studies reported here were not designed together, limiting direct comparisons. Nonetheless, the core motivation measures were based on Eccles and colleagues' (1995) measures in both, with slight variations. Both samples were predominantly White (73% for Australia, 90% for U.S.) and overrepresented middle-class families, limiting the study's generalisability to ethnic minority and lower socioeconomic background youth.

The longitudinal designs with two points in time add weight to inferences about influences on students' STEM-related career aspirations by the end of high school, although caution should be exercised in regard to causal inferences. It is tempting to interpret the finding that U.S. mothers' ratings of their adolescents' mathematics ability in 7th grade predicted the adolescents' self-concept of mathematics ability in 9th grade (see Fig. 2) as an indicator of the influence of maternal beliefs on children's self-concept. However, third-variable explanations are also possible. For example, the child's mathematics ability, demonstrated earlier through standardised tests or grades, may account for the mother's rating of her child's ability and the child's mathematics self-concept. This objection was addressed substantially by the inclusion in the model of measured mathematical performance, which means that other paths represent the significance of those relationships controlling for background mathematics achievement.

An important innovation was our use of continuous measures of the amount of mathematics, biology, chemistry, and physics knowledge required for the adult occupation preferred by the adolescent by the end of high school using O*NET 2011 scores (National Center for O*NET Development 2011). These scores allowed us to disaggregate patterns of prediction for mathematics-, physics-, chemistry-, and biology-related aspects of aspired careers. Such distinctions are particularly important when trying to understand gendered participation in diverse scientific fields. We believe this approach will prove useful to future research as we continue to work to understand why adolescents do, and do not, aspire to STEM-related careers.

In the current study, mathematics self-concept or performance was more important for female adolescents, and mathematics interest for male, in their STEM-related career choices. These findings contrast with previous research (Eccles and Vida 2003), including previous findings with this same Australian sample in relation to mathematics career plans (Watt et al. 2012). However, those analyses were based on an earlier O*NET coding (U.S. Department of Labor Employment and Training Administration 1998), which provided four less differentiated categories that could have attenuated relationships compared with the continuous scale of O*NET 2011. Moreover, O*NET 1998 focused on the *amount* of mathematics required in careers rather than the *knowledge* prerequisite to careers (as done in the current coding). Career characteristics and knowledge are also likely to have changed in the intervening 13 years. For example, the field of law increased on its mathematics O*NET code from 1998 to 2011, perhaps due to the increased reliance on scientific forms of evidence in litigation, and it was a career to which more of the Australian female than male adolescents had aspired. In contrast, the field of finance decreased in its mathematics requirements, possibly due to technological developments in the form of helpful software, and it was a career preferred more by male adolescents. The mathematics career results reported here are therefore not directly comparable to those reported by Watt et al. (2012).

Practice Implications

It was not the case that female adolescents showed a deficit in mathematics achievement as assessed by school grades or standardised tests. Despite this equivalence, female adolescents in the Australian sample held lower mathematics self-concept, which was more highly based on their prior achievements than males', suggesting that male adolescents' ability beliefs may be inflated. Interventions developed to counter stereotype threat effects show great promise for closing such gender gaps (Miyake et al. 2010). Another strategy is to work on the discrepancy between the gender difference in preferences for careers involving physics and the gender similarity in actual mathematical performance. Female adolescents need to know that they are scoring as well as male adolescents on these objective measures and that they can expect to be successful in mathematics-intensive careers. More pronounced gender differences in aspirations among the Australian sample raise the question of just how much choice should be offered to students in terms of participation in core STEM disciplines during high school.

Actual, or perceived, mathematical abilities were important for female adolescents' mathematics-related career plans in both samples. In the United States, for female but not for male adolescents, standardised mathematics test score in 10th grade predicted 12th grade preference for careers involving physics. In the Australian sample, perceived mathematical abilities predicted *each* of mathematics-, physics-, chemistry-, and biology-related career plans for Australian female adolescents, but not for males. In addition, female adolescents' self-concepts were significantly more closely tied to their previously demonstrated mathematical achievements than were males', supporting our anticipated gender differences in processes. The fact that female adolescents seemingly will not plan to pursue a STEM-related career unless they think they are good at it may stem from gender stereotypes, which magnify uncertainty or doubts about their success.

The role of interest was also affirmed in our study. Interest in mathematics was significantly linked to career physics, career mathematics, and career chemistry dimensions for male adolescents in the Australian sample. In the United States, mathematics interest linked to career mathematics for male adolescents, although measurement by a single item may have reduced precision and the ability to predict other variables (Cole and Preacher 2014). Why would mathematics interest be an important predictor of mathematics-intensive careers for male but not for female adolescents? The answer may lie in the pattern for actual or perceived abilities noted earlier and may be consistent with the original premise of the Eccles et al.'s (1983) expectancy-value model, which posits that only if individuals expect they can succeed *and* value mathematics will they enrol in advanced mathematics.

Did mathematics-related predictors impact career outcomes for biology, which is not a mathematics-intensive field in the way that physics is? Mathematics interest was unrelated to biology careers, for either female or male adolescents, in either sample. In the U.S. sample, none of the mathematics variables (self-concept, interest, importance, test scores, or mothers' perceptions) predicted biology-related career plans. However, mathematics self-concept did predict all STEM-related career dimensions for female adolescents (but not for males) in the Australian sample, and mathematics importance was predictive of biological career plans for male adolescents. Patterns of very high uniqueness between chemistry and biology career plans in both samples (especially for female adolescents) and between physics and chemistry career plans in the Australian sample implied that students (especially female adolescents) who had chemistry interests were more likely to plan to pursue biochemistry careers (both samples), and students with physics interests were more likely to plan to pursue physics/chemistry careers (see Table 6). Therefore, mathematics-related motivations are important for a range of STEM-related career plans, beyond mathematics-intensive careers, towards which promoting students' self-concepts and values is key.

According to expectancy-value theory, and the Parent Socialisation Model embedded within it, the beliefs of parents as socialisers exert an influence on their children's ability self-concept, values, and long-term goals (Chhin et al. 2008; Eccles et al. 1993b; Frome and Eccles 1998; Jacobs and Eccles 1992). Our results are consistent with this reasoning. The effects were stronger with the Australian sample, likely because students reported on their mothers' beliefs, whereas with the U.S. data, mothers reported their own beliefs. Additionally, mothers' perception data were collected earlier in the U.S. study (grade 7) than in the Australian study (grade 9) so that the former were a more distal influence. In both samples, mothers' perceptions of their child's mathematics ability correlated with the child's mathematics self-concept and interest. None of these correlations was gender-differentiated; that is, mothers' beliefs in their children's mathematics ability related similarly to female and male adolescents' mathematics self-concept and interest (as well as importance in the Australian sample).

Intriguingly, in the Australian sample, mothers' perceptions were significantly and substantially higher for sons than for daughters, at the same time as these were significantly and substantially more tied to students' actual mathematical achievements for daughters than for sons. These findings point to a gender bias in these mothers' judgments about sons versus daughters, or they reflect male and female adolescents' own differences in ability self-concepts. Stronger associations among the Australian sample reflect that students' perception of how the parent feels is more important to their motivations, perceptions, and decisions than parents' own reported perceptions (Goodnow 1988). These findings point to the importance of parents in encouraging or discouraging their adolescents' STEM career aspirations. Therefore, interventions to increase STEM participation may be able to target parents successfully (e.g., Harackiewicz et al. 2012).

Conclusions

In tune with the critical filter hypothesis, gender differences in mathematics-related motivations had consequences beyond mathematical career plans to diverse scientific career aspirations. Consequently, educators' and policymakers' attention to optimise positive student perceptions in mathematics should yield benefits for STEM participation more broadly. Patterns of gender differences and predictive variables varied considerably for mathematics and different sciences. In future research on gender and STEM, it will be important to differentiate biology, chemistry, and physics, rather than relying on aggregated measures of attitudes about science or STEM. At the same time, we need to understand the choices into which young women opt, instead of singularly focusing on why they opt out of particular STEM domains (Eccles 2013). This approach entails taking a dual focus to encompass the career choices that girls and young women actually make.

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References

Allison, P. D. (2001). *Missing data. Sage University papers series on quantitative applications in the social sciences, 07–136*. Thousand Oaks, CA: Sage.

Arbuckle, J. L. (1996). Full information estimation in the presence of incomplete data. In G. A. Marcoulides & R. E. Schumacker (Eds.), *Advanced structural equation modelling: Issues and techniques* (pp. 243–277). Mahwah, NJ: Erlbaum.

Australian Government Department of Education and Training. (2014). *UCube higher education data*. Retrieved from http://highereducationstatistics.education.gov.au/. Accessed 26 August 2016.

Ceci, S. J., & Williams, W. M. (2011). Understanding current causes of women's underrepresentation in science. *PNAS, 108*, 3157–3162. doi:10.1073/pnas.1014871108.

Charles, M., & Bradley, K. (2009). Indulging our gendered selves? Sex segregation by field of study in 44 countries. *American Journal of Sociology, 114*, 924–976. doi:10.1086/595942.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology, 6*(49), 2–8. doi:10.3389/fpsyg.2015.00049.

Chhin, C. S., Bleeker, M. M., & Jacobs, J. E. (2008). Gender-typed occupational choices: The long-term impact of parents' beliefs and expectations. In H. M. G. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes* (pp. 215–234). Washington, DC: American Psychological Association.

Cole, D. A., & Preacher, K. J. (2014). Manifest variable path analysis: Potentially serious and misleading consequences due to uncorrected measurement error. *Psychological Methods, 19*(2), 300–315. doi:10.1037/a0033805.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B. M., DuBois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrollment intentions: Gender similarities and differences. *Sex Roles, 52*, 351–367. doi:10.1007/s11199-005-2678-1.

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19*, 294–304. doi:10.1037/0893-3200.19.2.294.

Diekman, A. B., Clark, E. K., Johnson, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology, 101*, 902–918. doi:10.1037/a0025199.

Dobson, I. R. (2012). *Unhealthy science? University natural and physical sciences 2002 to 2009/10*. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/Unhealthy-Science-Report-Ian-R-Dobson.pdf. Accessed 26 August 2016.

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105–121). New York: Guilford.

Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist, 44*, 78–89. doi:10.1080/00461520902832368.

Eccles, J. S. (2013). Gender and STEM: Opting in versus dropping out. *International Journal of Gender, Science and Technology, 5*(3), 2–3. Retrieved from http://www.vhto.nl/fileadmin/user_upload/documents/publicaties/Gender_and_STEM_Opting_in_versus_dropping_out.pdf. Accessed 26 August 2016.

Eccles, J. S., & Vida, M. (2003, April). *Predicting mathematics-related career aspirations and choices*. Paper presented at the Society for Research in child development (SRCD) biennial conference, Tampa, FL.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*, 215–225. doi:10.1177/0146167295213003.

Eccles, (. P.). J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco: W. H. Freeman.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues, 46*, 183–201. doi:10.1111/j.1540-4560.1990.tb01929.x.

Eccles, J. S., Jacobs, J. E., Harold, R. D., Yoon, K. S., Abreton, A., & Freedman-Doan, C. (1993a). Parents and gender-role socialization during the middle childhood and adolescent years. In S. Oskamp & M. Costanzo (Eds.), *Gender issues in contemporary society, Claremont symposium on applied social psychology, 6* (pp. 59–83). Thousand Oaks, CA: Sage.

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993b). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64*, 830–847. doi:10.1111/j.1467-8624.1993.tb02946.x.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*, 103–127. doi:10.1037/a0018053.

Farmer, H. S., Wardrop, J. L., & Rotella, S. C. (1999). Antecedent factors differentiating women and men in science/nonscience careers. *Psychology of Women Quarterly, 23*, 763–780. doi:10.1111/j.1471-6402.1999.tb00396.x.

Frome, P. M., & Eccles, J. S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*, 435–452. doi:10.1037/0022-3514.74.2.435.

Goodnow, J. J. (1988). Parents' ideas, actions, and feelings: Models and methods from developmental and social psychology. *Child Development, 59*, 286–320. doi:10.2307/1130312.

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., Carter, S. M., & Elliot, A. J. (2000). Short-term and long-term consequences of achievement goals: Predicting interest and performance over time. *Journal of Educational Psychology, 92*, 316–330. doi:10.1037/0022-0663.92.2.316.

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., & Elliot, A. J. (2002). Predicting success in college: A longitudinal study of achievement goals and ability measures as predictors of interest and performance from freshman year through graduation. *Journal of Educational Psychology, 94*, 562–575. doi:10.1037/0022-0663.94.3.562.

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100*, 105–122. doi:10.1037/0022-0663.100.1.105.

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents motivate their adolescents in mathematics and science: An experimental test. *Psychological Science, 23*, 899–906. doi:10.1177/0956797611435530.

Harackiewicz, J. M., Canning, E. A., Tibbetts, Y., Priniski, S. J., & Hyde, J. S. (2016a). Closing achievement gaps with a utility-value intervention: Disentangling race and social class. *Journal of Personality and Social Psychology, 111*, 745–765. doi:10.1037/pspp0000075.

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016b). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences, 3*, 220–227. doi:10.1177/2372732216655542.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research, 60*, 549–571. doi:10.3102/00346543060004549.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the twenty-first century. *Review of Educational Research, 70*, 151–179. doi:10.3102/00346543070002151.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* American Association of University Women. Retrieved from https://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf. Accessed 26 August 2016.

Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *Science, 326*, 1410–1412. doi:10.1126/science.1177067.

Hulleman, C. S., Durik, A. M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology, 100*, 398–416. doi:10.1037/0022-0663.100.2.398.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880–895. doi:10.1037/a0019506.

Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist, 60*, 581–592. doi:10.1037/0003-066X.60.6.581.

Hyde, J. S., Klein, M. H., Essex, M. J., & Clark, R. (1995). Maternity leave and women's mental health. *Psychology of Women Quarterly, 19*, 257–285. doi:10.1111/j.1471-6402.1995.tb00291.x.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A., & Williams, C. (2008). Gender similarities characterize math performance. *Science, 321*, 494–495. doi:10.1126/science.1160364.

Inglehart, R., & Welzel, C. (2005). *Modernization, cultural change and democracy*. New York: Cambridge University Press.

Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63*, 932–944. doi:10.1037/0022-3514.63.6.932.

Lazarides, R., & Ittel, A. (2013). Mathematics interest and achievement: What role do perceived parent and teacher support play? A longitudinal analysis. *International Journal of Gender, Science and Technology, 5*(3), 207–231. Retrieved fromhttp://genderandset.open.ac.uk/index.php/genderandset/article/viewFile/301/526. Accessed 26 August 2016.

Leaper, C., Farkas, T., & Brown, C. S. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence, 41*(3), 268–282. doi:10.1007/s10964-011-9693-z.

Lindberg, S. M., Hyde, J. S., Petersen, J., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin, 136*, 1123–1135. doi:10.1037/a0021276.

Little, T. D. (1997). Mean and covariance structures (MACS) analyses of cross-cultural data: Practical and theoretical issues. *Multivariate Behavioral Research, 32*, 53–76. doi:10.1207/s15327906mbr3201_3.

Little, T. D. (2013). *Longitudinal structural equation modeling*. New York, NY: The Guildford Press.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*, 877–907. doi:10.1002/sce.20441.

Meece, J. L., Eccles, (. P.). J., Kaczala, C. M., Goff, S. B., & Putterman, R. (1982). Sex differences in math achievement: Toward a model of academic choice. *Psychological Bulletin, 91*, 324–348. doi:10.1037/0033-2909.91.2.324.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*, 60–70. doi:10.1037/0022-0663.82.1.60.

Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance. *Psychometrika, 58*(4), 525–543. doi:10.1007/BF02294825.

Miller, C. C. (2011, July 13). *Girl power wins at Google's first science fair*. New York Times. Retrieved from http://www.nytimes.com/2011/07/19/science/19google.html. Accessed 26 August 2016.

Miyake, A., Kost-Smith, L., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science, 330*, 1234–1237. doi:10.1126/science.1195996.

National Center for O*NET Development. (2011). *O*NET products at work*. Retrieved from https://www.onetcenter.org/dl_files/paw/Products_at_Work.pdf. Accessed 26 August 2016.

National Science Foundation. (2016). *Doctorate recipients by sex and subfield*. Retrieved from https://www.nsf.gov/statistics/2016/nsf16300/data-tables.cfm. Accessed 26 August 2016.

National Student Clearinghouse Research Center. (2013). *Snapshot report – degree attainment*. Retrieved from https://nscresearchcenter.org/snapshotreport-degreeattainment3/. Accessed 26 August 2016.

Osipow, S. H., & Fitzgerald, L. F. (1996). *Theories of career development* (4th ed). London: Allyn & Bacon.

Pomerantz, E. M., & Dong, W. (2006). Effects of mothers' perceptions of children's competence: The moderating role of mothers' theories of competence. *Developmental Psychology, 42*, 950–961. doi:10.1037/0012-1649.42.5.950.

Riegle-Crumb, C., & King, B. (2010). Questioning a white male advantage in STEM: Examining disparities in college major by gender and race-ethnicity. *Educational Researcher, 39*, 656–664. doi:10.3102/0013189X10391657.

Robnett, R. D., & Leaper, C. (2013). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence, 23*, 652–664. doi:10.1111/jora.12013.

Sells, L. W. (1980). Mathematics: The invisible filter. *Engineering Education, 70*, 340–341.

Shapka, J. D., Domene, J. F., & Keating, D. P. (2006). Trajectories of career aspirations through adolescence and young adulthood: Early math achievement as a critical filter. *Educational Research and Evaluation, 12*, 347–358. doi:10.1080/13803610600765752.

Shih, M. J., Pittinsky, T. L., & Ho, G. C. (2012). Stereotype boost: Positive outcomes from the activation of positive stereotypes. In M. Inzlicht & T. Schmader (Eds.), *Stereotype threat: Theory, process, and application* (pp. 141–156). New York: Oxford University Press.

Sorby, S., Casey, B. M., Veurink, N., & Dulaney, A. (2013). The role of spatial training in improving spatial and calculus performance in engineering students. *Learning and Individual Differences, 26*, 20–29. doi:10.1016/j.lindif.2013.03.010.

Steele, C. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613–629. doi:10.1037/0003-066X.52.6.613.

Steffens, J. C., Jelenec, P., & Noack, P. (2010). On the leaky math pipeline: Comparing implicit math-gender stereotypes and math withdrawal in female and male children and adolescents. *Journal of Educational Psychology, 102*, 947–963. doi:10.1037/a0019920.

STEPS. (2016). *STEPS: Study of Transitions and Educational Pathways*. Retrieved from http://www.stepsstudy.org/. Accessed 26 August 2016.

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin, 135*, 859–884. doi:10.1037/a0017364.

U.S. Department of Labor Employment and Training Administration. (1998). *O*NET: The occupational information network*. Washington, DC: U.S. Government Printing Office.

United States Census Bureau. (2006). *State and county quickfacts*. Retrieved from http://quickfacts.census.gov/qfd/states/55000.html. Accessed 26 August 2016.

Updegraff, K. A., Eccles, J. S., Barber, B. L., & O'Brien, K. M. (1996). Course enrollment as self-regulatory behavior: Who takes optional high school math courses? *Learning and Individual Differences, 8*, 239–259. doi:10.1016/S1041-6080(96)90016-3.

Wai, J., Lubinksy, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology, 101*, 817–835. doi:10.1037/a0016127.

Walton, G. M., & Cohen, G. L. (2003). Stereotype lift. *Journal of Experimental Social Psychology, 39*, 456–467. doi:10.1016/S0022-1031(03)00019-2.

Watt, H. M. G. (2002). *Gendered achievement-related choices and behaviours in mathematics and English: The nature and influence of self-, task- and value perceptions* (Unpublished PhD thesis). University of Sydney, Sydney, NSW, Australia.

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values and task perceptions according to gender and domain in 7th through 11th-grade Australian students. *Child Development, 75*, 1556–1574. doi:10.1111/j.1467-8624.2004.00757.x.

Watt, H. M. G. (2006). The role of motivation in gendered educational and occupational trajectories related to maths. *Educational Research and Evaluation, 12*, 305–322. doi:10.1080/13803610600765562.

Watt, H. M. G. (2008). What motivates females and males to pursue sex-stereotyped careers? In H. M. G. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 87–113). Washington, DC: American Psychological Association. doi:10.1037/11706-003.

Watt, H. M. G. (2016). Gender and motivation. In K. R. Wentzel & D. B. Miele (Eds.), *Handbook of motivation at school* (2nd ed., pp. 320–339). New York: Routledge.

Watt, H. M. G., Eccles, J. S., & Durik, A. M. (2006). The leaky mathematics pipeline for girls: A motivational analysis of high school enrolments in Australia and the USA. *Equal Opportunities International, 25*(8), 642–659. doi:10.1108/02610150610719119.

Watt, H. M. G., Shapka, J. D., Morris, Z. A., Durik, A. M., Keating, D. P., & Eccles, J. S. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. *Developmental Psychology, 48*, 1594–1611. doi:10.1037/a0027838.

Wigfield, A. (1993). Why should I learn this? Adolescents' achievement values for different activities. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (Vol. 8, pp. 99–138). Greenwich, CT: JAI Press.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review, 6*, 49–78. doi:10.1007/BF02209024.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68–81. doi:10.1006/ceps.1999.1015.