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Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: A multi-cohort study☆

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ABSTRACT

This study drew on expectancy-value theory (EVT) to examine the relations between mathematics motivation (academic self-concept and task values) and student background variables in predicting educational outcomes. Using latent-variable models with latent interactions, we investigated the multiplicative effect of self-concept and value, which is central to classic EVT. The mediating role of motivation and gendered patterns was also explored. Hong Kong's TIMSS dataset for three cohorts (1999, 2003, and 2007) was used over a period where the education system had experienced considerable changes, providing a strong test of the robustness of these findings. The results suggested: (a) self-concept is more important for students with lower utility values in predicting their educational outcomes; (b) while boys and girls had similar levels of math self-concept and values, girls tended to have higher mathematics achievement and educational aspirations; (c) family socioeconomic status is more strongly linked to educational aspirations for boys.

Expectancy-value theory (EVT), beginning with the seminal work of Atkinson (1957), continues to be one of the most dominant theories of achievement motivation (Eccles, 1994, 2009). EVT proposes that expectancy of success in a given task and the degree to which this task is valued are determinants of achievement-related performance and choices (Eccles, 1994, 2009). Although Eccles and her colleagues (Eccles, 1994, 2009; Eccles & Wigfield, 2002; Eccles (Parsons) et al., 1983) elaborated multiple components of subjective task values and linked motivational beliefs to other psychological, social, and cultural factors, the multiplicative relation between expectancy and value, which was the cornerstone of classic EVT (Atkinson, 1957), has been less researched. This gap could be due to the lack of advanced statistical techniques suited to measuring expectancy by value interactions. With recent developments of latent variable approaches to interaction effects, researchers are now able to more accurately analyze the latent interactions inherent in classic EVT (Marsh, Wen, & Hau, 2004; Nagengast et al., 2011; Trautwein et al., 2012). However, these empirical studies only considered one component of task values with expectancy when testing the interactive relation, which is inconsistent with the assumption of EVT that multiple task values simultaneously influence achievement-related outcomes.

In addition, in the EVT model, the association of children's backgrounds, including gender role socialization and family socioeconomic status (SES), with educational outcomes is believed to be mediated through expectancy and task values. Even though recent studies have demonstrated that motivational beliefs play a significant role in mediating the relation of gender and SES with educational outcomes (e.g., De la Fuente, Sander, & Putwain, 2013; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006; Nagy et al., 2008; Parker et al., 2012), few studies have considered both expectancy and multiple task values together and compared direct and indirect effects when investigating the mediating role of motivational beliefs.

Therefore, our aim is to provide a comprehensive test of EVT, including the multiplicative relation and mediating role of math expectancy and task values on math academic achievement and educational aspirations. Given that social and cultural processes are achievement-related behaviors (Eccles, 2009), we also explore gender differences in the relations of SES and motivational beliefs with educational outcomes, particularly in the multiplicative relation between expectancy and task values. For robustness of the analysis, we include data from multiple cohorts (1999, 2003, 2007) of Hong Kong students who participated in the Trends in International Mathematics and Science Study (TIMSS). The substantial changes in the Hong Kong education system resulting from major educational reforms from the year 2000

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(Education Commission, 2000) together with the handover of sovereignty from the UK to China in 1997 (Dimmock & Walker, 1997) provide us with an interesting context for testing the salience of EVT predictions. Specifically, consistency of results across this historically important period would provide a strong test of the robustness of predictions based on EVT.

1. Expectancy-value theory

The modern EVT model posits that achievement-related performance is most directly influenced by the individual's expectancies of academic success and a subjective assessment of the inherent value of the academic task. However, socialization processes linked to various cultural and social settings (e.g., school and family) introduce individual differences in motivational beliefs, leading to differential performance. Modern EVT (Eccles (Parsons) et al., 1983) defines expectancy of success as a task-specific belief about the possibility of experiencing future success in that task that is directly related to one's evaluation of one's competency within a specific academic domain (e.g., academic self-concept, Marsh, 1986). Following Eccles and colleagues (Eccles, 2009; Eccles & Wigfield, 2002; also see Nagengast et al., 2011; Nagy et al., 2008), here we use academic self-concept as a measure of expectancy of success.

Modern EVT distinguishes between multiple components of value (Eccles & Wigfield, 2002). In the current study, we focus on two value components: intrinsic value that refers to the enjoyment a person gains from performing an activity; and utility value, relating to how a specific task fits within individual future plans and objectives. Expectancy and value are both known to be domain specific (Eccles & Wigfield, 2002; Wigfield & Eccles, 2002). Research has shown that competence beliefs are related positively to several different dimensions of value within a specific domain, but that the relations involving intrinsic value seem to be the strongest (Wigfield & Eccles, 2002). In cross-sectional and longitudinal studies, there is growing evidence of expectancy beliefs having a strong influence on achievement, while value beliefs have stronger influence on choice, effort, and persistence in achievement-related activities (Gasco & Villarroel, 2014; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Nagengast et al., 2011; Trautwein et al., 2012).

2. Multiplicative effect of expectancy and task value

The classic EVT conceptualization emphasizes the presence of the multiplicative combination of expectancy and value (Atkinson, 1957). More precisely, both high expectancy beliefs and task values were seen as essential for attaining high academic achievement and guiding educational aspirations. That is, expectations and subjective values were proposed to combine multiplicatively to determine the outcomes (Feather, 1982). Nevertheless, tests of EVT models are primarily additive in nature (where two or more predictors uniquely and independently predict the outcome variable) rather than multiplicative. Over time, this has led to the disappearance of possible multiplicative interaction effects from EVT research (see Nagengast et al., 2011). A possible reason for the omission of the interaction term was the lack of appropriate methods for testing multiplicative relations (see Appendix A in Supplemental material for more discussion). However, applied researchers now have access to new methods for testing latent interactions. Nagengast et al. (2011) found significant multiplicative relations between self-concept and intrinsic value on extracurricular activities and aspirations across 57 countries based on the Programme for International Student Assessment (PISA) 2006 data. In a study with a German sample, Trautwein et al. (2012) also found evidence of the significant multiplicative effects of expectancy and four subcomponents of value (attainment, intrinsic value, utility value, and cost), each considered separately, on English and math achievements. These findings have yet to be replicated with a stronger analytic approach to examine multiple predictions of multiple outcomes across multiple data points within the same study.

3. Family background and gender

According to the EVT framework (Eccles, 2007, 2009), parents provide social–emotional influences on children's motivation beliefs which in turn influence children's educational performance and aspirations (Eccles, 2007, 2009). Because parents' beliefs and behaviors are associated with their socio-economic status (SES), families with higher SES are likely to produce more positive outcomes for children (Eccles, 2009). However, the majority of the literature on family SES has focused on direct, positive effects of SES on children's academic achievement (see Sirin, 2005 for a review), perceived competence and task beliefs (Eccles, 2007) and children's expectations of how far they will go in school (Halle, Kurtz-Costes, & Mahoney, 1997). More recent research has started to investigate the mediation effects of motivational beliefs, suggesting that the relations of SES to academic achievement and educational aspirations are partially mediated by motivation variables (Grolnick, Friendly, & Bellas, 2009).

Likewise, based on EVT (Eccles, 2009), gender exerts influences on achievement-related behaviors through its associations with motivational beliefs. In other words, gender differences in achievement-related behaviors are mediated by gender differences in motivational beliefs (Eccles, Barber, & Jozefowicz, 1999; Nagy et al., 2006, 2008; Simpkins, Davis-Kean, & Eccles, 2006). Multiple studies have reported more positive math self-concepts, attitudes and affect for males (Eccles & Wigfield, 2002; Marsh & Yeung, 1998; Marsh et al., 2013). However, in recent decades, growing evidence in cross-national meta-analyses (Else-Quest, Hyde, & Linn, 2010; Lindberg, Hyde, Petersen, & Linn, 2010) shows gender similarities in math achievement. Furthermore, there has been a dramatic increase in females' educational aspirations, and particularly in secondary school, females tend to report higher educational aspirations than their male counterparts (Schoon & Polek, 2011). Although the mediating role of motivation factors has been widely addressed in the literature (e.g., Parker et al., 2012), apparently no previous studies have considered both self-concept and multiple task values and their multiplicative effects simultaneously and examined the direct, indirect and total effects of gender and SES to educational outcomes.

In addition to mediation effects, gender also exerts moderation effects (Eccles, 2009; Nagy et al., 2006; Simpkins et al., 2006; Watt et al., 2012). However, research so far has yielded mixed evidence regarding gender differences when examining the relations among SES, motivational beliefs, and academic outcomes across different cultures. For example, math utility value was found to play a more important role for educational aspirations in Australian high school female samples, whereas the relation between math motivation beliefs and educational aspirations did not vary by gender in samples from the USA and Canada (Watt et al., 2012). In addition, the relation between SES and educational aspirations did not vary by gender in the UK sample (Schoon & Polek, 2011), whereas the relation was stronger for African-American males (Trusty, 2002). However, very little research has examined whether the relationships among SES, motivational beliefs, and educational outcomes, vary as a function of gender in an Asian context.

4. The Hong Kong context

In 1997, Hong Kong experienced its largest social change—the handover of sovereignty from the UK to China. Among the many effects of this change of government, there have been profound changes in the Hong Kong educational system. Since the changeover, a number of new initiatives have been implemented with the attempt to enhance the quality of school education. They include a Medium of Instruction Guidance for Secondary Schools to reinforce the 'biliterate and trilingual' policy (1998); support for information technology in education (1998); a series of new curriculum reforms (2001); and systemic and structural changes including basic competency assessments, changed structures in secondary and higher education, and the implementation of Liberal Studies as a new curriculum domain (2004; see Chong, 2012). These policies and initiatives at various levels (system, school, class, and student levels) have led to substantial changes in the Hong Kong educational system after the handover. In particular, the numbers of English-medium schools have significantly decreased from around ninety percent to only a quarter of secondary schools after Instruction Guidance was implemented (Zhu & Leung, 2011).

Within what they called a 'non-intervention period', Marsh, Hau, and Kong (2000) showed that the second-language medium (i.e., English in the Hong Kong Chinese context) had substantially negative effects on math achievement and academic self-concepts in other school subjects (see Appendix B in Supplemental material). Further to the change of medium of instruction for many students, education and curriculum reforms in math education have been successively implemented in Hong Kong since 1999 (Leung, 2006). These reforms have placed an increased emphasis on the enhancement of students' learning motivation (e.g., establishing confidence in and positive attitudes to math) (Education Commission, 2000). Nevertheless, influenced by the Confucian heritage culture that has a strong academic achievement orientation of the Chinese culture, Hong Kong students' intrinsic motivation is often dominated by extrinsic values (Luo, Hogan, Yeung, Sheng, & Aye, 2013; also see Appendix B in Supplemental material).

5. The present investigation

The purpose of this study was to investigate the multiplicative relations of expectancy and value on outcome variables, which seems to have disappeared from the modern EVT model (Nagengast et al., 2011; Trautwein et al., 2012). Further, we examine how students' background variables (gender and SES) predict self-concept and task values, which in turn influence math achievement and educational aspirations. Also, we explore whether the relationships among SES, motivational beliefs and outcomes, including the latent interaction, vary by gender. The hypothesized model (see Fig. 1) was built on the basis of the EVT framework (Eccles, 1994, 2009). First, we hypothesized math self-concept to be a stronger predictor of mathematics achievement, and value to be a stronger predictor of educational aspiration, when both expectancy and value are considered simultaneously (e.g., Eccles & Wigfield, 2002; Marsh et al., 2013). More importantly, we anticipated the multiplicative effect of self-concept and value on outcome variables to be significant, indicating that students with both high self-concept and value would be likely to have higher achievement and aspirations. Second, we expected that self-concept and task values would significantly mediate the relationships between SES and gender and educational outcomes. Third, given the absence of a strong empirical basis for making predictions about whether the associations among SES, motivational beliefs and academic outcomes will function differently for boys and girls, we treat the gender moderation analysis as a research question. Finally, despite the huge societal changes in Hong Kong with the change in government, we expected robust effects predicted by EVT outlined above to remain relatively unaffected.

6. Method

6.1. Participants

The target population was Hong Kong Grade 8 students who participated in the TIMSS 1999, 2003 and 2007 waves. TIMSS employed a very efficient method to attain accurate and representative samples through a two-stage sampling procedure (e.g., Mullis et al., 2000). The first stage comprised a sample of schools; the second comprised a single classroom selected randomly from the different grades in the sampled schools (Martin, Mullis, Foy, & Olson, 2008). As a result of this selection process in Hong Kong, the 5179 students (49.3% girls, 50.7% boys), 4972 (50.4% girls, 49.6% boys), and 3470 (50.4% girls, 49.6% boys) formed the three samples in the present study. The average age of these students was 14.4 at the time of TIMSS testing in 1999 (Mullis et al., 2000), 2003 (Mullis, Martin, Gonzalez, & Chrostowski, 2004), and 2007 (Martin et al., 2008).

6.2. Measures

The measures of the student background variables (gender and SES), expectancy-value constructs and achievement-related and aspiration outcomes were selected from the student-background questionnaire. All motivation items were answered on a 4-point Likert scale (from 1 "disagree a lot" to 4 "agree a lot"). Higher values represented more favorable responses (see Appendix C in Supplemental material).

Expectancy. The math self-concept scale was used to assess students' expectancy of success. The scale consisted of four items in TIMSS 2003 and 2007, but five items in TIMSS 1999 (e.g., "I usually do well in mathematics"). Reliability of this scale was good (Cronbach's alpha $\alpha = .772$ to .808).

Task value. TIMSS (see Olson, Martin, & Mullis, 2008) created a scale of Students' Positive Affect Toward Mathematics (PATM) to assess the affect experienced when participating in math-related activities (e.g., "I enjoy learning mathematics"), in line with the notion of *intrinsic value* (MIV) in the modern EVT (Eccles (Parsons) et al., 1983). Likewise, the TIMSS Students Valuing Mathematics (SVU) scale is similar to *utility value* (MUV) in the modern EVT (Eccles (Parsons) et al., 1983), which assesses how well math achievement relates to current and future goals (e.g., "I need to do well in mathematics to get the job I want"). These two constructs demonstrated very good reliability across three cohorts ($\alpha = .763$ to 863).

Academic achievement. Students' math achievement used in the present study was derived from the TIMSS math test. TIMSS relied on Item Response Theory (IRT) scaling to assess achievement and obtain accurate

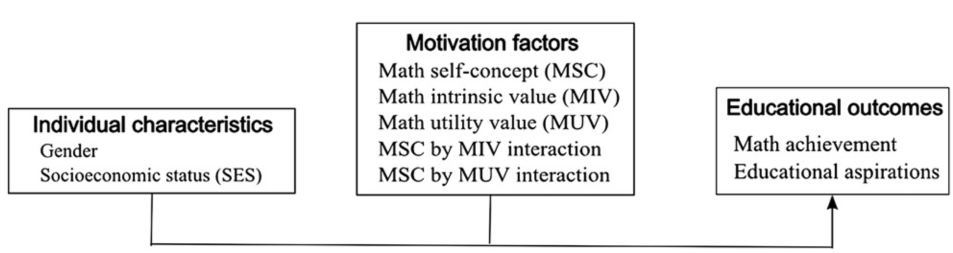

Fig. 1. The hypothesized model.

measures of trends from previous assessments. TIMSS IRT scaling approach uses multiple imputations to provide proficiency scores in math for each student, even if each student responds only to a part of the item pool (Martin et al., 2008). Five plausible values were estimated for each student for attaining comparable achievement scores in order to obtain unbiased estimates.

Educational aspirations. A single item was used in the three waves of data to assess students' education aspirations ("How far in school do you expect to go?"). The response scale ranged from finishing upper secondary school to beyond bachelor program.

Background variables. SES was assessed with a scale including three items including the highest educational level of father and mother and the number of books at home. Reliability of this scale was good ($\alpha = .707$ to 740). Gender was self-reported and coded 0 for girls and 1 for boys, so that positive coefficients indicate higher scores for boys.

6.3. Data analysis

Within a structural equation modeling (SEM) framework, we used the latent moderated structural (LMS) equation approach (Klein & Moosbrugger, 2000) to model the latent interactions between expectancy and value beliefs in predicting the outcome variables with Mplus 7.11 (Muthén & Muthén, 1998–2013). LMS directly models the implied non-normal distribution of the latent outcome variables and its indicators (Kelava et al., 2011). Consistent with the assumptions of LMS, all Confirmatory Factor Analysis (CFAs) and SEMs were estimated using robust maximum likelihood (MLR) estimation (Klein & Moosbrugger, 2000).

In addition, all analyses were based on TIMSS' HOUWGT weighting variable that incorporates three components related to sampling of the school, class and student respectively, and three associated with non-participation at the levels of school, class and student (for more details on the incorporation of weights in analyses, see Marsh et al., 2013). All models were estimated while taking into account individuals' nesting within classes and schools using the design-based correction of standard errors available in Mplus 7.11 (using the TYPE = COMPLEX option, see Muthén & Muthén, 1998–2013).

6.3.1. Missing data

Multiple imputations were used to account for missing responses (Graham, Cumsille, & Elek-Fisk, 2003). Multiple imputation procedures have been shown to be robust to departures from normality assumptions and to provide unbiased results even for low sample sizes or high rates of missing data (Graham et al., 2003). For each cohort, five imputed data sets were created and one of the five sets of plausible achievement scores was used with each of the imputed data sets. The final parameter estimates, standard errors and goodness-of-fit statistics of the structural equation model (SEM) with latent interaction were obtained with the automatic aggregation procedure implemented in Mplus 7.11 (Rubin, 1987). Furthermore, we used a standard meta-analysis approach (see Hox, 2010; Lipsey & Wilson, 2001) to provide aggregated estimates for the path coefficients of each cohort (i.e., the weighted mean effect size and standard errors; see Appendix D in Supplemental material).

6.3.2. Negatively worded items

Method effects associated with negative item wording have been reported in many studies (DiStefano & Motl, 2006; Marsh, 1986; Marsh & O'Mara, 2008; Marsh, Scalas, & Nagengast, 2010). These effects are likely to have adverse effects on goodness of fit, parameter estimates, and substantive interpretations. Correlations between the uniquenesses of all negatively worded items (two self-concept items and one intrinsic motivation item) were thus included to the model (Marsh et al., 2013; also see Appendix H in Supplemental material for example syntax).

6.3.3. Goodness of fit

A number of indices were used to assess model fit. Tucker–Lewis Index (TLI) and the Comparative Fit Index (CFI) with values greater than .90 and .95 typically reflect acceptable and excellent fit to the data respectively. For the Root Mean Square Error of Approximation (RMSEA), values of less than .06 and .08 reflect a close fit and a minimally acceptable fit to the data respectively. For model comparisons, decrease in fit for the more parsimonious model is less than .01 for incremental fit indices like the CFI or less than .015 for the RMSEA, then there is reasonable support for the more parsimonious model (Chen, 2007; Cheung & Rensvold, 2002).

7. Results

7.1. Descriptive statistics and correlations

Descriptive statistics are presented in Table 1. All of the scales are approximately normally distributed. Although multi-item scales demonstrated acceptable internal reliability at three cohorts, the fact that some items have modest factor loading reinforces the importance of using latent variables models that include a natural control for measurement errors (see Appendix C in Supplemental material). CFA was used to evaluate the patterns of correlations among motivation factors (MSC, MIV and MUV) and outcome variables (math achievement and

Table 1
Sample size, distribution characteristics, means, and (standard deviation) of variables by cohort and gender.

Variables	MSC	MIV	MUV	SES	ASP	ACH
1999						
Skewness	.63	−.16	0	−.59	−1.09	−.42
Kurtosis	.51	0	−.21	.58	.54	.7
Mean(SD)						
Boys (N = 2624)	2.69 (.88)	2.67 (.69)	2.63 (.65)	3.37 (.76)	4.22 (1.16)	567.01 (65.98)
Girls (N = 2554)	2.59 (.81)	2.56 (.61)	2.39 (.63)	3.50 (.66)	4.44 (1.02)	565.40 (57.94)
2003						
Skewness	.08	.03	−.29	.70	−1.09	−.58
Kurtosis	−.40	−.26	.57	.45	.97	.61
Boys (N = 2466)	2.62 (.68)	2.56 (.69)	2.97 (.58)	3.06 (1.26)	3.92 (1.21)	581.42 (68.49)
Girls (N = 2506)	2.32 (.66)	2.37 (.66)	2.93 (.54)	3.06 (1.24)	4.04 (1.05)	583.9 (64.44)
2007						
Skewness	.04	−.23	−.47	.87	−.89	−.52
Kurtosis	−.34	−.52	.79	.42	.92	.14
Boys (N = 1748)	2.65 (.68)	2.69 (.80)	2.99 (.63)	2.73 (1.17)	4.22 (1.28)	563.42 (88.41)
Girls (N = 1722)	2.35 (.65)	2.55 (.75)	2.93 (.58)	2.75 (1.11)	4.26 (1.04)	569.88 (77.71)

aspirations). Across the three waves, similarly high intercorrelations among motivation factors were observed (see Appendix E in Supplemental material). Math self-concept was closely associated with math intrinsic value (mean [M] $r = .772$, $SE = .019$). In terms of correlations between motivation factors and outcomes, self-concept was more strongly correlated with math achievement (M $r = .434$, $SE = .019$), while utility value was more strongly associated with educational aspirations (M $r = .358$, $SE = .016$). Achievement was moderately correlated with aspirations (M $r = .432$, $SE = .030$).

7.2. The hypothesized model

In our hypothesized model (Fig. 1), the effects of background variables on math achievement and educational aspirations were mediated by expectancy and values (self-concept, intrinsic value, and utility value) and the latent interactions (self-concept by intrinsic value, self-concept by utility value) influenced the outcome variables. The SEM model fitted the data well in all three samples (2007 model: $\chi^2 = 1526.877$, $df = 283$, CFI = .969, TLI = .962, RMSEA = .050; 2003 model: $\chi^2 = 1911.819$, $df = 254$, CFI = .978, TLI = .974, RMSEA = .051; 1999 model: $\chi^2 = 3193.741$, $df = 499$, CFI = .927, TLI = .917, RMSEA = .050). The total amount of variance explained was also similar across waves: 28% for math achievement and 27% for educational aspirations in TIMSS 1999, compared to 25% and 25% respectively in TIMSS 2003, and 26% and 25% respectively in TIMSS 2007. The effect sizes for the direct path coefficients of the standardized solution are shown in Fig. 2, while those for the indirect path coefficients are presented in Table 2 (also see Appendix F in Supplemental material).

7.3. Expectancy by task value

The path coefficients from self-concept and intrinsic and utility values to outcome variables were similar across the three cohorts (Fig. 2). Consistent with a priori predictions, the positive path from self-concept to achievement was much stronger than the corresponding paths from intrinsic value and utility value to achievement (i.e., main effects). However, also consistent with predictions, the path from utility value to aspirations was greater than the corresponding path from self-concept. However, in contrast to a rich body of empirical research (Denissen, Zarret, & Eccles, 2007; Durik, Vida, & Eccles, 2006), the mean effect sizes across the three cohorts for the path from intrinsic value to achievement and to aspirations were not statistically significant. This could be due to the high correlation noted between intrinsic value and self-concept (expectancy), leading intrinsic value to have no unique effect on outcome variables when expectancy and values are considered together.

A key contribution of the present study is the simultaneous testing of two critical interactions. Consistent with our hypothesis, the multiplicative predictive effects of self-concept and utility value on math achievement and educational aspirations were both statistically significant. The simple-slopes (Preacher, Rucker, & Hayes, 2007) graphed in Fig. 3 showed that self-concept positively predicted achievement at different levels of utility value. However, particularly at lower levels of utility value, self-concept predicted achievement more positively than at higher levels of utility value. When self-concept was at nearly one standard deviation above the mean, different levels of utility value tended to predict similar levels of achievement. Likewise, a significant interaction between self-concept and utility value was also evident for educational aspirations (Fig. 3), showing that when utility value is low, self-concept contributes more positively to aspiration. Nevertheless, the predictive effects of self-concept on achievement at different levels of utility value were much stronger than those on aspiration, such that self-concept was the dominant predictor of achievement. The results suggest that higher self-concept, higher utility value, and their positive interaction, all contributed to higher math achievement and educational aspiration.

In interpreting the latent interaction on aspiration, we need to note that all constructs are math-specific while the aspirations construct is composed of a single general indicator. Given that expectancy and values are highly domain specific, a student who has high verbal self-concept or interest may contribute to his or her high aspirations in educational attainment. Likewise, and inconsistent with our expectations, the intrinsic value by self-concept interaction is not significantly

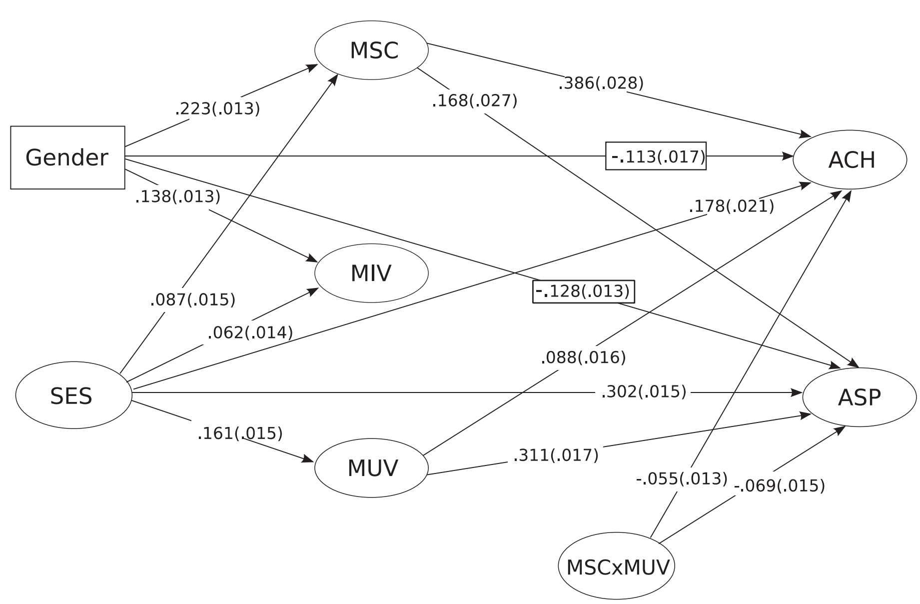

Fig. 2. Path model depicted the hypothesized relations. Only weighted mean effect size (standard errors) for statistically significant paths was presented in the model for clarity. Estimates displayed in rectangle box indicted the negative path coefficients. *Note.* MSC = mathematics self-concept; MIV = mathematics intrinsic value; MUV = mathematics utility value; SES = socioeconomic status; ACH = mathematics achievement; ASP = educational aspiration. MSC × MIV = mathematics self-concept by intrinsic value interaction. MSC × MUV = mathematics self-concept by utility value interaction.

Table 2
The direct, indirect and total effects of gender and SES on outcome variables.

Outcomes variables		Direct effect	Indirect effect			Total effect
			Via MSC	Via MIV	Via MUV	
Gender						
Math achievement	1999	−.090* (.028)	.052* (.019)	.005 (.012)	.001 (.002)	−.032 (.043)
	2003	−.116* (.027)	.102* (.014)	−.002 (.007)	.004* (.002)	−.012 (.055)
	2007	−.141* (.034)	.074* (.012)	.011 (.005)	.003 (.003)	.053 (.034)
	Mean(*SE*)	−.113* (.017)	.080* (.008)	.006 (.004)	.003 (.002)	.014 (.024)
Educational aspirations	1999	−.163* (.023)	.024* (.009)	−.018 (.011)	.008 (.006)	−.149* (.022)
	2003	−.099* (.019)	.026* (.011)	−.011 (.007)	.016* (.008)	−.068* (.040)
	2007	−.136* (.024)	.027* (.011)	−.003 (.004)	.009 (.006)	−.103* (.021)
	Mean(*SE*)	−.128* (.013)	.029* (.007)	−.006 (.004)	.010* (.004)	−.114* (.014)
Socioeconomic status (SES)						
Math achievement	1999	.175* (.041)	.038* (.013)	.002 (.007)	.014* (.006)	.229* (.043)
	2003	.164* (.032)	.032* (.010)	−.001 (.002)	.014* (.004)	.209* (.025)
	2007	.201* (.038)	.039* (.011)	.008 (.005)	.013* (.003)	.261* (.040)
	Mean(*SE*)	.178* (.021)	.036* (.006)	.001 (.002)	.013* (.002)	.225* (.019)
Educational aspirations	1999	.290* (.025)	.018* (.009)	−.008 (.005)	.054* (.009)	.354* (.020)
	2003	.290* (.024)	.008* (.004)	−.003 (.003)	.052* (.010)	.347* (.019)
	2007	.334* (.029)	.014* (.007)	−.002 (.003)	.045* (.010)	.391* (.021)
	Mean(*SE*)	.302* (.015)	.012* (.003)	−.003 (.002)	.051* (.006)	.364* (.012)

Note. t value > 1.96, * $p < .05$; MSC = mathematics self-concept; MIV = mathematics intrinsic value; MUV = mathematics utility value.

predictive of either achievement or aspirations. However, again this may be due to the high correlation between these self-concept and intrinsic value.

7.4. SES and gender

As shown in Fig. 2, the positive direct effects of SES on motivational beliefs and educational outcomes indicate that students from a high SES family were likely to have more positive motivation and higher math achievement and educational aspirations. More importantly, the indirect paths from SES to the educational outcomes were also significant and positive, showing the positive mediation by both self-concept and utility value. Consistent with a priori predictions and previous studies, our findings suggest that SES positively predicts achievement-related behaviors, directly or indirectly, by promoting self-concept and subjective task values (Parker et al., 2012; Schoon & Polek, 2011).

The observed predictive direct effect of gender on motivational beliefs indicates that boys tend to have high math self-concept and intrinsic value but not utility value, which is line with previous Western studies of gender stereotypes (Watt et al., 2012; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). It is interesting to note that the direct path from gender to achievement was largely off-set by the corresponding indirect path. This finding suggests that boys are likely to have higher math self-concept, which leads to higher math achievement (the indirect path from gender), whereas girls tend to have higher math achievement when girls and boys have similar levels of self-concept and intrinsic value (the direct path from gender). Taken together, there was no gender difference in math achievement in terms of total effect. In relation to educational aspirations, the direct path favoring girls was only partially countered by the corresponding indirect path favoring boys. In total, educational aspirations favored girls to a small extent. This finding is in line with our expectations and the recently

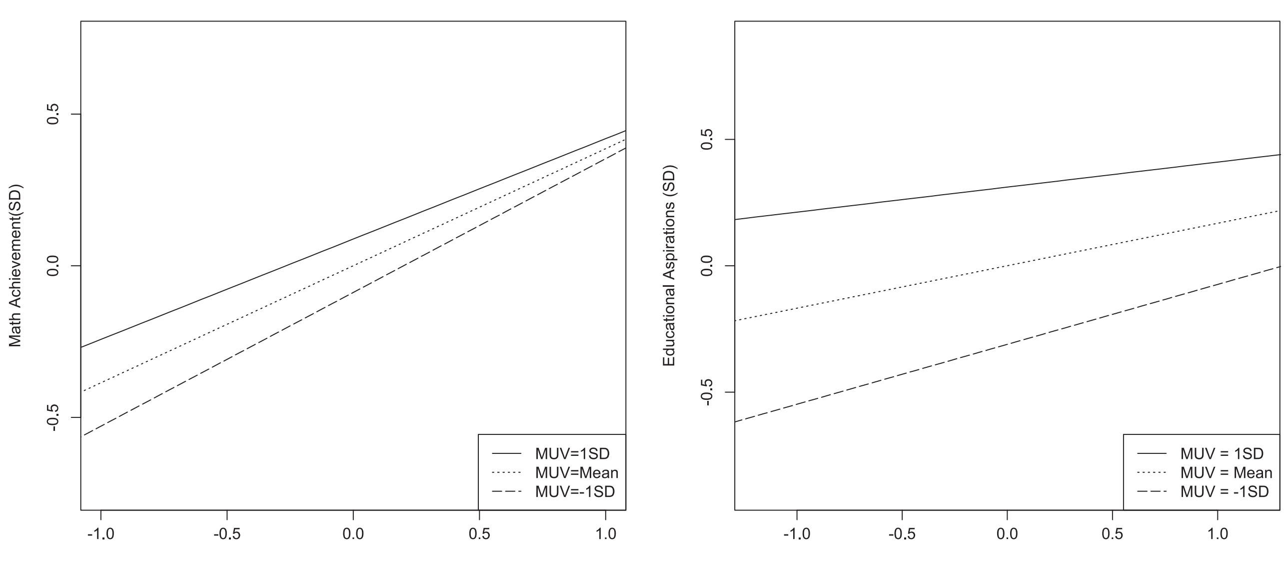

Fig. 3. Simple-slopes depicted the effects of the latent-interaction variables (self-concept by utility value) on mathematics achievement and educational aspirations. *Note.* MSC = mathematics self-concept; MUV = mathematics utility value.

observed change in gender difference on educational attainment favoring girls (see Appendix F in Supplemental material).

Additionally, to test whether the relationships among SES, motivational beliefs and educational outcomes vary as a function of gender, we conducted multigroup analysis in which gender was treated as a grouping variable. We found that SES was more strongly associated with aspirations for boys than for girls (gender differences in magnitude of the path coefficient: 2007 model: ES = .125, SE = .043; 2003 model: ES = .094, SE = .040; 1999 model: ES = .116, SE = .040). This finding indicates that family SES is more important for boys' educational aspirations (see Appendix G in Supplemental material).

8. Discussion

In sum, drawing on EVT this study contributes to the literature by identifying the mediating and interactive roles of math self-concept and subjective task values in the relationships between individuals' characteristics (gender and SES) and mathematics achievement and educational aspiration. The results have substantive importance for EVT. First, statistically significant interaction suggests that routinely checking for potential interaction effect is needed for future studies using the Eccles et al. (EVT) model. Second, the consistent patterns of effects observed across three cohorts during this naturally occurring “intervention” provide strong evidence for the robustness of EVT predictions. Third, given that little research has examined the moderating role of gender based on EVT in an Asian context, our results have shed light on the gendered processes underlying students' choice of educational pathway.

At this stage, it is important to reinforce that the three cohorts considered in the present study related to a period in which the educational context in Hong Kong was changing substantially. For example, the new math curriculum and a series of new education policies were implemented at the same time of the handover of sovereignty from the UK to China in 1997. Further complicating the patterns is the fact that the instruments used to measure key constructs differed slightly across cohorts. However, despite these complications, the patterns of results were highly consistent, supporting the external validity of the results (see Shadish, Cook, & Campbell, 2002), and proving strong support to the robustness of the theory.

Nevertheless, limitations must also be taken into account. First, it is not clear how these results generalize to Western countries or to other Asian countries. Chiu and Xihua (2008) demonstrated that the effects of family characteristics on children's math achievement are stronger in individualistic and more affluent countries. Second, SES was narrowly defined and did not include parents' income and occupation. Third, in the present study, educational aspiration was a general rather than domain-specific construct, and was represented by a single item. Given that both expectancy and task values are highly domain specific (Eccles & Wigfield, 2002), there is a need for items to assess students' intention of studying math or taking up a math-related career. Fourth, prior studies have documented that teaching processes play a critical role in the development of various components of self-related beliefs in school contexts (e.g., De la Fuente & Justicia, 2007). Therefore, it is important to take teaching–learning processes into consideration in further motivation research. Fifth, this study could not address the issue of causality (or even directionality) between demographic or motivational factors and outcomes based on a single measurement point. It is always possible that models with a reversed direction (e.g., from aspirations to motivational beliefs) may exist in reality. Finally, replication of findings may benefit also from alternative statistical techniques (e.g., Rasch modeling) instead of SEM.

Our findings have important implications for policy, practice, and intervention. First, given the positive effects of the interaction between expectancy and value on educational outcomes, it is important that teachers place emphasis on simultaneously enhancing students' expectancy and value beliefs, with special attention on strengthening self-concept for those with lower utility value. For example, teaching strategies and methodologies based on an interactive conception of teaching–learning and building achievement motivation have shown an essential contribution in promoting students' motivation (e.g., De la Fuente & Justicia, 2007). Second, despite evidence of negligible gender differences in math achievement, there is a continuing pattern of gender stereotypic differences in favor of boys in perceptions of competence and interest in math. These gender differences might lead to underrepresentation of girls in math-related fields (Parker et al., 2012), which is an important concern. Further, although the Hong Kong government has been seeking to reduce inequalities based on family wealth via progressive taxes, social support programs, and tuition-free schools since the early 2000s (OECD, 2004), inequalities continue to be evident in the close relation between SES and children's motivation and educational outcomes, even in the TIMSS 2007 cohort. Thus, stronger and more powerful steps in reducing inequalities on SES could help students, particularly boys, to not only improve their motivation but also achieve better academic outcomes.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.lindif.2015.01.008.

References

Atkinson, J.W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, *64*(Part 1(6)), 359–372.

Chen, F.F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling*, *14*, 464–504. http://dx.doi.org/10.1080/10705510701301834.

Cheung, G.W., & Rensvold, R.B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*, *9*, 233–255. http://dx.doi.org/10.1177/109442810143004.

Chiu, M.M., & Xihua, Z. (2008). Family and motivation effects on mathematics achievement: Analyses of students in 41 countries. *Learning and Instruction*, *18*(4), 321–336. http://dx.doi.org/10.1016/j.learninstruc.2007.06.003.

Chong, S. (2012). The Hong Kong policy of quality education for all: A multi-level analysis of its impacts on newly arrived children. *International Journal of Inclusive Education* (April 2013), 37–41.

De la Fuente, J., & Justicia, F. (2007). The DEDEPRO model of regulated teaching and learning: Recent advances. *Electronic Journal of Research in Educational Psychology*, *5*(3), 535–564.

De la Fuente, J., Sander, P., & Putwain, D. (2013). Relationship between undergraduate student confidence, approach to learning and academic performance: The role of gender. *Journal of Psychodidactics*, *18*(2), 373–391.

Denissen, J.J.A., Zarrett, N.R., & Eccles, J.S. (2007). I like to do it, I'm able, and I know I am: Longitudinal couplings between domain-specific achievement, self-concept, and interest. *Child Development*, *78*(2), 430–447. http://dx.doi.org/10.1111/j.1467-8624.2007.01007.x.

Dimmock, C., & Walker, A. (1997). Hong Kong's change of sovereignty: School leader perceptions of the effects on educational policy and school administration. *Comparative Education*, *33*(2), 277–302. http://dx.doi.org/10.1080/03050069728578.

DiStefano, C., & Motl, R.W. (2006). Further investigating method effects associated with negatively worded items on self-report surveys. *Structural Equation Modeling: A Multidisciplinary Journal*, *13*(3), 440–464. http://dx.doi.org/10.1207/s15328007sem1303_6.

Durik, A.M., Vida, M., & Eccles, J.S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology*, *98*(2), 382–393.

Eccles, J.S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly*, *18*, 585–609.

Eccles, J.S. (2007). Families, schools, and developing achievement-related motivations and engagement. In J.E. Grusec, & P.D. Hastings (Eds.), *Handbook of socialization* (pp. 665–691). New York, NY: Guilford Press.

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*(2), 78–89. http://dx.doi.org/10.1080/00461520902832368.

Eccles (Parsons), J.S., Adler, T.F., Futterman, R., Goff, S.B., Kaczala, C.M., Meece, L.J., et al. (1983). Expectancies, values, and academic behaviors. In J.T. Spence (Ed.), *Achievement and achievement motivation: Psychological and sociological approaches* (pp. 75–146). San Francisco, CA: Freeman.

Eccles, J.S., Barber, B., & Jozefowicz, D. (1999). Linking gender to educational, occupational, and recreational choices: Applying the Eccles et al. model of achievement-related choices. In W.B. Swann, J.H. Langlois, & L.A. Gilbert (Eds.), *Sexism and stereotypes in modern society: The gender science of Janet Taylor Spence* (pp. 153–192). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/10277-007.

Eccles, J.S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132.

Education Commission (2000). *Learning for life, learning through life: Reform proposals for the education system in Hong Kong.* Hong Kong: Government Printer.

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*(1), 103–127. http://dx.doi.org/10.1037/a0018053.

Feather, N.T. (1982). Expectancy-value approaches: Present status and future directions. In N.T. Feather (Ed.), *Expectations and actions: Expectancy-value models in psychology* (pp. 395–420). Hillsdale, NJ: Erlbaum.

Gasco, J., & Villarroel, J.D. (2014). The motivation of secondary school students in mathematical word problem solving. *Electronic Journal of Research in Educational Psychology*, *12*(1), 83–106. http://dx.doi.org/10.14204/ejrep.32.13076.

Graham, J.W., Cumsille, P.E., & Elek-Fisk, E. (2003). Methods for handling missing data. In A.S. Velicer, & W.F. Velicer (Eds.), *Research methods in psychology* (pp. 87–114). New York: John Wiley & Sons.

Grolnick, W.S., Friendly, R., & Bellas, V. (2009). Parenting and children's motivation at school. Handbook of motivation at school. In K.R. Wenzel, & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 279–300). New York, NY: Routledge/Taylor & Francis.

Halle, T.G., Kurtz-Costes, B., & Mahoney, J.L. (1997). Family influences on school achievement in low-income, African American children. *Journal of Educational Psychology*, *89*(3), 527–537.

Hox, J.J. (2010). *Multilevel analysis: Techniques and applications.* UK: Routledge Academic.

Kelava, A., Werner, C.S., Schermelleh-Engel, K., Moosbrugger, H., Zapf, D., Ma, Y., et al. (2011). Advanced nonlinear latent variable modeling: Distribution analytic LMS and QML estimators of interaction and quadratic effects. *Structural Equation Modeling: A Multidisciplinary Journal*, *18*(3), 465–491. http://dx.doi.org/10.1080/10705511.2011.582408.

Klein, A., & Moosbrugger, H. (2000). Maximum likelihood estimation of latent interaction effects with the LMS method. *Psychometrika*, *65*(4), 457–474.

Leung, K.S.F. (2006). Mathematics education in East Asia and the West: Does culture matter? In F.K. -S. Leung, K. -D. Graf, & F.J. Lopez-Real (Eds.), *Mathematics education in different cultural traditions a comparative study of East Asia and the West* (pp. 21–46). New York: Springer.

Lindberg, S.M., Hyde, J.S., Petersen, J.L., & Linn, M.C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin*, *136*(6), 1123–1135. http://dx.doi.org/10.1037/a0021276.

Lipsey, M.W., & Wilson, D.B. (2001). *Practical meta-analysis.* Thousand Oaks, CA: Sage Publications.

Luo, W., Hogan, D.J., Yeung, A.S., Sheng, Y.Z., & Aye, K.M. (2013). Attributional beliefs of Singapore students: Relations to self-construal, competence and achievement goals. *Educational Psychology*. http://dx.doi.org/10.1080/01443410.2013.785056.

Marsh, H.W. (1986). Verbal and math self-concepts: An internal/external frame of reference model. *American Educational Research Journal*, *23*(1), 129–149.

Marsh, H.W., Abduljabbar, A.S., Abu-Hilal, M., Morin, A.J.S., Abdelfattah, F., Leung, K.C., et al. (2013). Factorial, convergent, and discriminant validity of TIMSS math and science motivation measures: A comparison of Arab and Anglo-Saxon countries. *Journal of Educational Psychology*, *105*(1), 108–128. http://dx.doi.org/10.1037/a0029907.

Marsh, H.W., Hau, K.T., & Kong, C.K. (2000). Late immersion and language of instruction in Hong Kong high schools: Achievement growth in language and nonlanguage subjects. *Harvard Educational Review*, *70*(3), 302–347.

Marsh, H.W., & O'Mara, A.J. (2008). Reciprocal effects between academic self-concept, self-esteem, achievement, and attainment over seven adolescent years: Unidimensional and multidimensional perspectives of self-concept. *Personality and Social Psychology Bulletin*, *34*(4), 542–552.

Marsh, H.W., Scalas, L.F., & Nagengast, B. (2010). Longitudinal tests of competing factor structures for the Rosenberg Self-Esteem Scale: Traits, ephemeral artifacts, and stable response styles. *Psychological Assessment*, *22*(2), 366–381. http://dx.doi.org/10.1037/a0019225.

Marsh, H.W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development*, *76*(2), 397–416. http://dx.doi.org/10.1111/j.1467-8624.2005.00853.x.

Marsh, H.W., Wen, Z., & Hau, K.T. (2004). Structural equation models of latent interactions: Evaluation of alternative estimation strategies and indicator construction. *Psychological Methods*, *9*(3), 275–300. http://dx.doi.org/10.1037/1082-989x.9.3.275.

Marsh, H.W., & Yeung, A.S. (1998). Longitudinal structural equation models of academic self-concept and achievement: Gender differences in the development of math and English constructs. *American Educational Research Journal*, *35*(4), 705–738. http://dx.doi.org/10.3102/00028312035004705.

Martin, M.O., Mullis, I.V.S., Foy, P., & Olson, J.F. (2008). *TIMSS 2007 international mathematics report.* Boston, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., & Chrostowski, S.J. (2004). *TIMSS 2003 international mathematics report.* Chestnut Hill, MA: International Study Center, Lynch School of Education, Boston College.

Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., Gregory, K.D., Garden, R.A., & O'Connor, K.M. (2000). *TIMSS 1999: international science report.* Chestnut Hill, MA: International Study Center, Boston College, Lynch School of Education.

Muthén, L.K., & Muthén, B. (1998–2013). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nagengast, B., Marsh, H.W., Scalas, L.F., Xu, M.K., Hau, K. -T., & Trautwein, U. (2011). Who took the "x" out of expectancy-value theory? A psychological mystery, a substantive-methodological synergy, and a cross-national generalization. *Psychological Science*, *22*(8), 1058–1066. http://dx.doi.org/10.1177/0956797611415540.

Nagy, G., Garrett, J., Trautwein, U., Cortina, K., Baumert, J., & Eccles, J.S. (2008). Gendered high school course selection as a precursor of gendered careers: The mediating role of self-concept and intrinsic value. In H.M.G. Watt, & J.S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 115–143). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/11706-004.

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation*, (February 2013), 37–41. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/13803610600765687

OECD (2004). *PISA learning for tomorrow's world: First results from PISA 2003.* Paris, France: Author.

Olson, J.F., Martin, M.O., & Mullis, I.V.S. (2008). *TIMSS 2007 technical report.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center.

Parker, P.D., Schoon, I., Tsai, Y. -M., Nagy, G., Trautwein, U., & Eccles, J.S. (2012). Achievement, agency, gender, and socioeconomic background as predictors of postschool choices: A multicontext study. *Developmental Psychology*, *48*(6), 1629–1642. http://dx.doi.org/10.1037/a0029167.

Preacher, K.J., Rucker, D.D., & Hayes, A.F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research*, *42*(1), 185–227. http://dx.doi.org/10.1080/00273170701341316.

Rubin, D.B. (1987). *Multiple imputation for nonresponse in surveys.* New York: John Wiley & Sons.

Schoon, I., & Polek, E. (2011). Teenage career aspirations and adult career attainment: The role of gender, social background and general cognitive ability. *International Journal of Behavioral Development*, *35*(3), 210–217. http://dx.doi.org/10.1177/0165025411398183.

Shadish, W.R., Cook, T.D., & Campbell, D.T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Belmont, CA: Wadsworth.

Simpkins, S.D., Davis-Kean, P.E., & Eccles, J.S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70–83. http://dx.doi.org/10.1037/0012-1649.42.1.70.

Sirin, S.R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417–453. http://dx.doi.org/10.3102/00346543075003417.

Trautwein, U., Marsh, H.W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy–value theory: A latent interaction modeling study. *Journal of Educational Psychology*, *104*(3), 763–777. http://dx.doi.org/10.1037/a0027470.

Trusty, J. (2002). African Americans' educational expectations: Longitudinal causal models for women and men. *Journal of Counseling & Development*, *80*(3), 332–345. http://dx.doi.org/10.1002/j.1556-6678.2002.tb00198.x.

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*(6), 1594–1611. http://dx.doi.org/10.1037/a0027838.

Wigfield, A., & Eccles, J.S. (2002). The development of competence beliefs and values from childhood through adolescence. In A. Wigfield, & J.S. Eccles (Eds.), *Development of achievement motivation* (pp. 92–120). San Diego, CA: Academic Press.

Wigfield, A., Eccles, J.S., Schiefele, U., Roeser, R.W., & Davis-Kean, P. (2006). Development of achievement motivation. In N. Eisenberg, W. Damon, & R.M. Lerner (Eds.), *Handbook of child psychology (6th ed.). Social, emotional, and personality development, Vol. 3.* (pp. 933–1002). Hoboken, NJ: Wiley (Retrieved from www.csa.com).

Zhu, Y., & Leung, F. (2011). Mathematics achievement of mainland immigrant students in Hong Kong. *Asia Pacific Journal of Education*, (January 2013), 37–41. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/02188791.2011.621673