Expectancy-Value, Gender and Socioeconomic Background as Predictors of Achievement and Aspirations: A Multi-cohort Study

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Highlights

- Expectancy is a stronger predictor of mathematics achievement than mathematics utility value is of educational aspiration.
- Gender difference in educational outcomes was partially explained by self-concept and utility value.
- Family socioeconomic status had positive effects on educational outcomes, and some of this effect was mediated by expectancy and value.
- Higher self-concept, higher utility value, and their interaction, all contributed to higher educational outcomes.
- The pattern of the effects investigated was generally consistent across all three waves of TIMSS data.

Running head: EXPECTANCY-VALUE

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Abstract

This study examined the relationship between mathematics expectancy (self-concept), value and student background variables in predicting educational outcomes. In particular, we investigated the effects of the interaction between expectancy and value on outcome variables and the mediating roles of expectancy and value. The research used data from the TIMSS database across three cohorts (1999, 2003, and 2007) to test an hypothesized model in Hong Kong, where the education system has experienced considerable changes over the period of these studies, and thus to provide a strong test of the generalizability of the findings. The results suggested that (a) gender difference in educational outcomes was partially explained by self-concept and utility value; (b) family socioeconomic status had a positive effect on educational outcomes, and some of this effect was mediated by expectancy and value; (c) higher self-concept, higher utility value, and their interaction, all contributed to higher educational outcomes.

Keywords: expectancy-value theory, mathematics achievement, educational aspiration, gender

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1. Introduction

School achievement and educational aspirations are critical predictors of subsequent academic

success (e.g., Jimerson, Egeland, & Teo, 1999; Schmidt & Hunter, 1998). A rich body of research has

indicated that academic achievement among students is influenced by cognitive and non-cognitive

variables (e.g., Eccles et al., 1983; Karbach, Gottschling, Spengler, Hegewald, & Spinath, 2013).

Non-cognitive predictors include motivation (e.g., Denissen, Zarrett, & Eccles, 2007; Marsh,

Trautwein, Lüdtke, Köller, & Baumert, 2005; Wigfield & Eccles, 2002) and background factor (e.g.,

gender, socioeconomic status, etc,; e.g., Grolnick, Friendly, & Bellas, 2009; Hyde, Fennema, &

Lamon, 1990). Numerous studies attest to the impact of demographic background variables on

students' academic achievement and educational aspirations (e.g., Else-Quest, Hyde, & Linn, 2010;

Grolnick, et al., 2009; Parker et al., 2012). However, recent studies suggest that the relation between

demographic background variables and educational outcomes may be mediated by psychological

factors such as expectancy (individuals' expectation of success) and subjective task value (e.g.,

Eccles, 1994; Grolnick, et al., 2009; Nagy, Trautwein, & Baumert, 2006; Nagy et al., 2010; Parker, et

al., 2012; Schoon, 2008). Recent research has begun to pay close attention to expectancy by value

interaction, which was the cornerstone of classic expectancy-value theory (EVT) (Atkinson, 1957) but

which has been less researched in modern EVT (Eccles, et al., 1983). This gap could be due to the

lack of advanced statistical techniques and methodologies suited to measuring expectancy by value

interaction. However, with the recent development of advanced substantively-grounded

methodologies, 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).

1.1. Expectancy-Value Theory

The modern EVT model (Eccles, 1994; Eccles, et al., 1983; Eccles & Wigfield, 2002; Wigfield

& Eccles, 2002), developed from classic EVT (Atkinson, 1957), proposes that while individuals'

expectations of success and subjective task value directly predict achievement-related choices and

performances, they are affected by a number of psycho-social factors. Modern EVT (e.g., Eccles, 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 individuals' evaluations of their competencies, or domain-specific self-conceptions (e.g. academic self-concept, Marsh, 1986). Although ability beliefs (or self-concepts) and expectancy of successes are theoretically distinct constructs, these two constructs are empirically indistinguishable in real-life settings (Eccles & Wigfield, 2002; Wigfield & Eccles, 1992, 2002). For this reason we use academic self-concept in the current research as a measure of expectancy of success.

Also, modern EVT distinguishes between among components of value (Wigfield & Eccles, 1992). For the present purposes we distinguish between *intrinsic value,* referring to the enjoyment a person gains from performing an activity, in line with intrinsic motivation and interest, 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, 1995; Eccles, Wigfield, Harold, & Blumenfeld, 1993). For example, *verbal* (comprising native language, second language, reading, writing etc.) and *mathematical* (comprising math, physics, economics, etc.) expectancy-related beliefs form distinct factors in children as young as six (Eccles & Wigfield, 1995; Eccles, et al., 1993). Not only does the domain specificity of these different constructs increase with students' age, but also the positive associations between expectancy and value beliefs within a particular domain continue to increase in strength over time (e.g., Eccles & Wigfield, 2002; Wigfield & Eccles, 2002; Wigfield, Tonks, & Klauda, 2009). Research has shown that competence beliefs relate positively to several different dimensions of value, but that relations involving intrinsic value are the strongest (Eccles & Wigfield, 1995; Wigfield & Eccles, 2002). Expectancy and value beliefs significantly influence educational outcomes (Denissen, et al., 2007; Durik, Vida, & Eccles, 2005; Eccles, 1993; 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 (Marsh, et al., 2005; Nagengast, et al., 2011; Trautwein, et al., 2012; Wigfield et al., 1997). Interestingly, children's expectancy and value beliefs for different tasks seem to decrease as they mature (Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006).

1.2. Expectancy by Value interaction

The classic EVT emphasizes the presence of a synergistic relationship between expectancy and value (Atkinson, 1957). More precisely, both expectancy of success on a task and high belief in value are seen as essential to high achievement. For example, if a student does not expect to succeed on a task, low achievement-related outcomes are likely, even in the presence of high value beliefs. Likewise, low value beliefs should also result in lower achievement-related outcomes, even when combined with high expectancy beliefs. Hence, expectations and subjective values are proposed to combine multiplicatively to determine the outcome (Feather, 1982). However, in many studies based on the original EVT model, neglecting the fact that expectancies and values are more naturally represented as continuous variables, expectancy or value beliefs were experimentally manipulated to be "zero" (Trautwein, et al., 2012).

However, modern EVT models are additive in nature, where two (or more) predictors uniquely and independently predict the outcome variable. Over time, a greater emphasis on non-experimental studies, and the lack of testing synergistic relations, has led to the disappearance of possible multiplicative interaction effects from EVT research. A possible reason for the omission of the expectancy by value interaction from modern applications relates to the lack of appropriate methods for testing multiplicative relations. However, applied researchers now have access to newer methods for testing latent interactions (Klein & Moosbrugger, 2000; Marsh, et al., 2004; Trautwein, et al., 2012). In recent times, Trautwein et al. (2012), in a study based on German secondary school data using the latent moderated structural (LMS) equation approach (Klein & Moosbrugger, 2000, see below) reported that the multiplicative term expectancy by four subcomponents of value beliefs (attainment, intrinsic value, utility value and cost) had statistically significant and positive effects on mathematics and science achievement (Trautwein, et al., 2012). However, the LMS equation approach has not been used for testing the generalization of multiplicative effects on other outcome variables and in large-scale cross-national data sets such as TIMSS, making it hard to assess the generalizability of these results. In the present study, based on the LMS equation approach, two outcome variables (mathematics achievement and educational aspiration) across three cohorts of TIMSS data (1999, 2003 and 2007) were used to explore the generalizability of the expectancy by

value interaction that forms the core proposition of classic EVT. Modern EVT theory is encapsulated in a wider Achievement Related Choices model by Eccles and colleagues (Eccles, 1994). In this framework, both expectancies and values are partially a product of demographic variables such as gender and socioeconomic status.

1.3. Background factors (Gender and Socioeconomic Status)

Gender. Commonly held stereotypes about male superiority in mathematics and science (Bhana, 2005; Hyde, et al., 1990) are in direct contrast to growing evidence in cross-national meta-analyses (Else-Quest, et al., 2010; Hyde, et al., 1990; Lindberg, Hyde, Petersen, & Linn, 2010) of gender similarities in math achievement. However, studies report higher mathematics self-concepts for males (Marsh et al., 2013; Marsh & Yeung, 1998; Wigfield, et al., 1997) and positive mathematics attitudes and affect (Else-Quest, Hyde and Linn; 2010). These gender differences, however, tend to disappear for the utility value of mathematics (Eccles, et al., 1983; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). These motivation factors tend to influence subsequent achievement and course choices at the individual level (Betz & Hackett, 1983; Marsh, 1991; Marsh & Yeung, 1998). As noted by many scholars in Western-based research, gender predicts educational outcomes both directly and indirectly, via motivation variables such as self-concept and intrinsic value (Eccles, 1994; Nagy, et al., 2006; Nagy, et al., 2010).

Socioeconomic Status. The majority of the literature on family socio-economic status (SES) pertains to the direct, positive effect of SES on children's academic achievement (Chiu & Xihua, 2008; Hampden-Thompson & Johnston, 2006; Jimerson, et al., 1999). The literature also suggests that SES influences the beliefs and behaviors of the parents, with higher SES leading to more positive outcomes for children (Eccles, 1993, 1994). In a variety of studies, parental beliefs and behaviors (e.g., gender-role stereotypes, expectations of children's performance) have been shown to predict children's perceived competence and task beliefs (Eccles, 2007; Fredricks & Eccles, 2002, 2005; Frome & Eccles, 1998) and children's own expectations of how far they will go in school (Halle, Kurtz-Costes, & Mahoney, 1997; Phillips, 1987). Although the studies presented above were based on Western countries, the effects of SES are consistent across cultures (Grolnick, et al., 2009; Phillipson & Phillipson, 2007). Further, recent research has documented that the effect of SES on academic

achievement and educational aspiration is partially mediated by children's motivation variables (Grolnick, et al., 2009; Schoon, 2008).

As mentioned above, the research suggests that motivation factors are important mediators in relations between demographic background and educational outcomes (e.g., Eccles, 1994; Nagy, et al., 2006; Nagy, et al., 2010; Parker, et al., 2012). However, few studies have considered both self-concept and task value simultaneously, when investigating the mediating role of motivation factors. In the current study, both mathematics self-concept and task value were taken into consideration as mediators, to further explore the exact nature of the relations between gender and SES, and mathematics achievement and educational aspiration.

The Hong Kong Context

Since the handover of sovereignty from the UK to China in 1997, the Hong Kong government has continuously increased investment in education. In addition, a number of policies have been initiated that are focused on enhancing the quality of school education. For example, a Medium of Instruction Guidance for Secondary Schools policy, introduced in 1997; information technology (1998); a new curriculum (2001); basic competency assessment, changed structures in secondary and higher education, and the implementation of Liberal Studies, in 2004 (see Chong, 2012). Although Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) data reflect that the mathematics achievement of Hong Kong students was always in the top ranking in international comparative studies (Martin, Mullis, Foy, & Olson, 2008; OECD, 2004), few studies have been conducted to explore whether the relations between students' individual-level factors and mathematics achievement remained consistent after substantial changes in the education system. Further, these major changes in the Hong Kong education system provide an opportunity to explore the generalizability of the expectancy by value interaction that is the core assumption of EVT theory. This study provides a clearer picture of Hong Kong students' mathematics learning by investigating the relationship between students' individual-level factors and their mathematics achievement, using three waves of the TIMSS data (1999, 2003, and 2007); one of the main International educational data sets available today.

Furthermore, in relation to mathematics education, the reforms have been successively

implemented in Hong Kong since 2000. The mathematics educational reform assigns a central role to the enhancement of students' learning motivation (e.g. establishing confidence in and positive attitudes to mathematics; (Education Commission, 2000). Even though the nature and the effects of motivation factors on achievement in Asian societies like Hong Kong have been scrutinized (Ho, 2007; Marsh & Hau, 2004; Rao, Moely, & Sachs, 2000), the role of motivational factors as potential mediators of the relation between students' background variables (gender and socioeconomic status) and educational outcomes, a main focus of the present study, still has been little explored.

With regard to gender differences in mathematics, a 2010 meta-analysis based on two major international data sets, the TIMSS 2003 and the PISA 2003, found that gender differences in mathematics achievement in Hong Kong students of 14-16 years age were very small (d = -0.03[1] in TIMSS; d = 0.04 in PISA; (Else-Quest, et al., 2010). Nonetheless, boys reported more positive mathematics self-concept and affect in both data sets (d = 0.43 in TIMSS, d = 0.24 in PISA for self-concept; d = 0.19 in TIMSS, d = 0.12 in PISA for affect; (Else-Quest, et al., 2010). In addition, gender differences in educational attainment have substantially changed from 1997 to 2007. The percentage of girls enrolled in higher education programs at undergraduate level has steadily increased from 49.6% in 1997 to 53.0% in 2007 (Census and Statistics Department, 2007). Similarly, the proportion of girls enrolled in research postgraduate study underwent a notable increase—from 29.5% to 42.2%. Thus, by 2007, significantly more girls than boys were enrolled in university study (54.1% vs. 45.9%; Census and Statistics Department, 2007); this is in line with studies conducted in Western countries (Organisation for Economic Co-Operation Development, 2007; Goldin, Katz, & Kuziemko, 2006). However, these crucial changes have received little attention in research of students' educational outcomes and aspirations.

1.4. The Current Research

The purpose of the present study was to examine the relationship between student background variables (gender and family socioeconomic status) and educational outcomes (mathematics achievement and educational aspiration), as well as the possible mediating role of mathematics

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[1] Positive values for d represent higher scores for males than females, whereas negative values represent higher scores for females.

expectancy and value. Also, we investigated the effect of the critical interaction between expectancy and value on outcome variables, the cornerstone of classic EVT (Atkinson, 1957) which has however disappeared from the modern EVT model (Trautwein, et al., 2012). To explore the generalizability of the results in the Hong Kong context, where there have been substantial changes in the education system since the handover of sovereignty from the UK to China in 1997, we used a large sample of Hong Kong Grade 8 students from three waves of TIMSS data (1999, 2003, and 2007). Under the framework of Eccles et al.'s, (1983) model, expectancy and value emerge from children's cultural background, including gender role socialization and family demographics (see Eccles & Wigfield, 2002 for a review). These two factors are critical in shaping how young people think about themselves, the values they hold and, as a result, what academic pathways they pursue (see Eccles, 1994). In the current study, the hypothesized model was built on the basis of this framework, and gender, family socioeconomic status, expectancy beliefs, different dimensions of task value, standardized mathematics achievement and educational aspiration were assessed and included in the hypothesized model (see Fig 1).

Our main research hypotheses were as follows. First, in view of the conceptual differentiation in the EVT model (Eccles et al., 1983) and previous empirical findings, we expected that both expectancy and value would have positive effects on mathematics achievement and educational aspirations. Furthermore, in relation to previous research on the effects of expectancy and/or value (e.g., Marsh et al, 2013; Nagengast et al., 2011; Trautwein et al., 2007) we anticipated expectancy to be a stronger predictor of mathematics achievement, and value to have a more positive effect on educational aspirations, when both expectancy and value are considered simultaneously. Second, in line with previous research, we expect only a marginal (or non-significant) effect of gender on mathematics achievement. However, we expect a significant effect of gender on educational aspirations (with higher aspirations for girls), as well as positive effects of SES on achievement and educational aspirations. Third, on the basis of classic EVT model, we expected the interaction effect of expectancy and value to be significant and supportive of a synergistic relation. Fourth, we expected that the pattern of effects investigated would be consistent across three waves of TIMSS data, illustrative of the robustness of these effects even in the context of substantial changes to the

educational system (see Shadish, Cook, & Campbell, 2002).

2. Method

2.1. Participants

In this study the target population was formed by Hong Kong Grade 8 students who participated in the TIMSS 1999, 2003 and 2007 waves. In regard to the sampling approach, 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 et al., 2008). As a result of this selection process in Hong Kong, the 5,179 (49.3% for girls, 50.7% for boys), 4,972 (50.4% for girls, 49.6% for boys), and 3,470 (50.4% for girls, 49.6% for boys), Grade 8 students who participated in TIMSS 1999, 2003 and 2007 formed the sample 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) 2007; Martin, Mullis, Foy, & Olson, 2008).

2.2. Measures

The measures of the student background variables (gender and socioeconomic status), expectancy-value constructs and achievement-related and aspiration outcomes were selected from the student-background questionnaire administered for TIMSS 1999-2007. However, it should be noted that the items assessing motivation were not entirely consistent across TIMSS 1999, 2003 and 2007. All motivation items were coded on a four-point Likert scale, with 1 indicating that the participants "agree a lot" and 4 indicating "disagree a lot". However, for the present purposes, responses were reverse-scored, so that higher values represented more favorable responses and thus, higher levels of motivation (see Appendices 1-3 in Supplemental Material for more detail regarding the items used; see also subsequent discussion of Table 1). For this reason, direct statistical comparison of the three cohorts was not feasible and thus we have utilized a pattern matching approach for integration of the results (see Parker et al., 2012).

Expectancy. The mathematics self-concept scale was used to assess students' expectancy of success. The scale consisted of four items measuring students' perception of their competencies in

mathematics in TIMSS 2003 and 2007, but five items in TIMSS 1999 (e.g., "I usually do well in mathematics").

Value. TIMSS (e.g., Olson, Martin, & Mullis, 2008 in TIMSS2007 Technical Report) created a scale of Students' Positive Affect Toward Mathematics (PATM) to assess the affect students experienced when participating in mathematics-related activities (e.g., "I enjoy learning mathematics"), in line with the notion of *intrinsic value* in the modern EVT (Eccles, et al., 1983). Likewise, the TIMSS Students Valuing Mathematics (SVU) scale was similar to *utility value* in the modern EVT (Eccles, et al., 1983), which assesses how well mathematics achievement relates to current and future goals (e.g., "I need to do well in mathematics to get the job I want"). These two scales consisted of different items in different waves of TIMSS data (see Appendices 1-3 in Supplemental Material for more details).

Achievement outcome. Students' mathematics achievement used in the present study derives from the TIMSS mathematics test. TIMSS relied on Item Response Theory (IRT) scaling to assess student achievement and to obtain accurate measures of trends from previous assessments. The TIMSS IRT scaling approach uses multiple imputation methodology to provide proficiency scores in mathematics for each student, even if each student responds only to a part of the assessment item pool (Martin et al., 2008). Five plausible values were estimated for each student for attaining comparable achievement scores in other to obtain unbiased estimates.

Educational aspiration. 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 finish <ISCED3>[2] to beyond <ISCED 5a[3], first degree>.

Background variables. SES was assessed with a scale including three items that assessed the highest educational level of father and mother and the number of books at home (e.g., "The highest level of education of your mother"). Gender was assessed with a single item and coded as "0" for girls, "1" for boys, so that positive coefficients indicate higher scores for boys.

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[2] ISCED3: Upper secondary school
[3] *ISCED5:*Tertiary programs (first stage) with academic orientation (type A; see Appendix 1 for more detail)

Data analysis

Weighting and clustering. Consistent with its two-stage stratified sampling design, TIMSS provides HOUWGT weighting variables. HOUWGT has six components, one each for school, class and student level, and one each for adjustment factors associated with non-participation at these three levels. HOUWGT is based on the actual number of each cohort in Hong Kong that is appropriate for correct computation of standard errors and tests of statistical significance. Thus, all models were estimated taking into account the HOUWGT weighting variable. Similarly, the nesting of the students into classes was also treated as a clustering variable in all models.

Missing data. Multiple imputation (Graham, Cumsille, & Elek-Fisk, 2003; Schafer & Graham, 2002) was used to account for missing responses to the items in this study. Multiple imputation produces unbiased parameter estimates reflecting the uncertainty associated with estimating missing data. The advantage of using multiple imputation is that it has been shown to be robust to departures from normality assumptions and provides adequate results even for low sample sizes or high rates of missing data (Graham, et al., 2003). For multiple imputation, 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 (Muthén & Muthén, 1998-2012), based on (Rubin, 1987).

Negatively worded items. Method effects associated with negative item wording have been reported for many scales (DiStefano & Motl, 2006). The construct irrelevant variance of negatively worded items tends to detract from the construct validity of interpretations (Marsh, 1986; Marsh et al., 2013). These effects are likely to have substantial effects on goodness of fit, parameter estimates, and substantive interpretations. Correlated uniquenesses between negatively worded items are generally used to test for negative-item method effects (Marsh, 1986; Marsh & O'Mara, 2008; Marsh, Scalas, & Nagengast, 2010). Correlated uniquenesses were thus added between the negatively worded items (two self-concept items and one intrinsic motivation item) used to measure motivational constructs in TIMSS 2007 to control for this negative-item bias (Marsh et al. 2013).

Latent interaction modeling. Within a structural equation modeling (SEM) framework, we used

the latent moderated structural (LMS) equation approach (Klein & Moosbrugger, 2000) to model the

latent interaction between expectancy and value beliefs in predicting the outcome variables (Muthén

& Muthén, 1998-2012; see Appendix 6 for the annotated input code). The advantage of using the

LMS approach is that it does not require the manual specification of product variables. Instead, it

models the implied non-normal distribution of the latent outcome variables and its indicators (Kelava

et al., 2011). Consistent with the assumptions of the LMS approach, all models were estimated using

the Mplus robust maximum likelihood (MLR) estimator (Klein & Moosbrugger, 2000). Although

research suggests that alternative estimators could be preferable for the estimation of models based on

Likert items, more recent studies suggest that categorical estimation procedures make little or no

difference to the parameter point estimates and may even detract from the precision of estimation

when the Likert items have four or more answer categories (e.g., Beauducel & Herzberg, 2006;

DiStefano & Motl, 2006; Rhemtulla, Brosseau-Liard, & Savalei, 2012).

Goodness of fit. Chi-square tests of statistical significance present a known oversensitivity to

sample size and minor model misspecifications; this made them irrelevant to the present investigation,

given the large sample sizes involved and the fact that all a priori SEM models tend to be false to

some extent when tested with a sufficiently large sample size (Marsh, Wen & Hau, 2004). Hence, in

applied SEM research, there is a predominant focus on indices that are sample sized (Marsh, Wen &

Hau, 2004; Marsh et al., 2012), such as the Root Mean Square Error of Approximation (RMSEA), the

Tucker-Lewis Index (TLI), and the Comparative Fit Index (CFI)—as well as chi-square test statistics

and evaluation of parameter estimates. Values greater than .90 and .95 for TLI and CFI respectively

typically are acceptable and provide excellent fit to the data. RMSEA values of less than .06 and .08

respectively are considered to reflect good and acceptable fits to the data.

3. Results

In order to test the factorial validity of the hypothesized model, we first computed a confirmatory

factor analytic model (CFA; see Appendices 1-3 for more detail). Second, we conducted a SEM in

order to examine the direct and indirect (i.e. mediated) associations between gender and SES as

predictors, mathematics expectancy and value as intermediate variables (i.e., mediators), and

mathematics achievement and educational aspiration as outcomes. In order to test the classic

interaction effect, we also considered two multiplicative effects (self-concept by intrinsic value and self-concept by utility value) on outcome variables. Given the similar sample size across three cohorts, 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).

3.1. Correlations among motivation factors and outcome variables

Before testing the hypothesized model, the patterns of correlations among motivation factors and outcome variables were evaluated across three waves of TIMSS data (see Appendices 4 & 5). Although TIMSS has not been entirely consistent in the way that motivation items were scored in different data collections (e.g., Olson, et al., 2008), similar high intercorrelations among motivation factors were found across the three waves considered in this study. Mathematics self-concept is closely associated with mathematics intrinsic value (mean [M] r = .772, SE = .019). In terms of correlations between motivation factors and outcomes, self-concept was more strongly correlated with mathematics achievement (M r = .434, SE = .019), while utility value was more strongly associated with educational aspirations (M r = .358, SE = .016). Achievement was modestly correlated with aspirations (M r = .432, SE = .030). In summary, despite the high intercorrelations among motivation factors, self-concept had a higher correlation with achievement, whereas utility value was more strongly related to educational aspirations.

3.2. The hypothesized model

In our hypothesized model (see Figure 1), the effects of background variables on mathematics achievement and educational aspiration were mediated by expectancy and value (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: [χ^2= 1456.953, df = 148 CFI = 0.971, TLI = 0.962, RMSEA = 0.050; 2003 model: χ^2= 1718.142, df = 133,CFI = 0.984, TLI = 0.979, RMSEA = 0.049; 1999 model: χ^2= 3215.986, df = 233, CFI = 0.919, TLI = 0.904, RMSEA = 0.050]). The total amount of variance explained was also similar across waves: 28% for mathematics achievement and 27% for educational aspiration in TIMSS 1999, compared to 25% and 25% respectively in TIMSS 2003, and 26% and

25% respectively in TIMSS 2007, are explained. The path coefficients of the completely standardized

solution are shown in Table 1.

3.3. Effects of expectancy and value beliefs on outcome variables

The path coefficients of predictive relations between expectancy and value beliefs and outcome

variables were similar across the three cohorts. Mathematics self-concept was the stronger predictor of

achievement (M effect size [ES] = .386, SE = .028) and utility value slightly and positively influenced

achievement (M ES = .088, SE = .016). However, the mean effect size across the three cohorts for the

association between intrinsic value and achievement was not statistically significant, even though this

association was marginally significant for the 2007 cohort. Regarding the prediction of educational

aspirations, the effect size for utility value (M ES = .311, SE = .017) was larger than that for self-

concept (M ES = .168, SE = .027), while intrinsic value did not have a statistically significant effect.

3.4. Direct and indirect effect of background variables on outcome variables

Gender had modest effects on self-concept in favor of boys (M ES = .223, SE = .013) and

intrinsic value (M ES = .138, SE = .013), but no statistically significant effect on utility value.

Controlling for motivation factors, the direct effect of gender on achievement was negative and

significant (M ES = -.113, SE = .017), while the corresponding indirect effect of gender on

achievement via self concept was positive and significant (M ES = .080, SE = .008). Similarly, gender

had a negative and significant direct effect on aspiration (M ES = -.128, SE = .013), and a significant

positive—yet weak—indirect effect via both self-concept (M ES = .029, SE = .007) and utility value

(M ES = .010, SE = .004). In summary, these results suggest that girls tend to have higher levels of

achievement and aspirations (direct effects), but that over and above these direct effects, boys tend to

present higher levels of self-concept and utility value, two factors themselves associated with higher

levels of achievement and aspiration (indirect effects).

With respect to SES, it had a stronger positive effect on utility value (M ES = .161, SE = .015)

than on self-concept (M ES = .087, SE = .015) and intrinsic value (M ES = .062, SE = .014). SES also

had a substantial and significant positive direct effect on aspirations (M ES = .302, SE = .015) and

achievement (M ES = .178, SE = .021). Over and above this direct effect, SES also presented a

significant positive indirect effect on achievement and aspirations, as positively mediated by both self-

concept (M ES = .036, SE = .006 for achievement; M ES = .012, SE = .003 for aspirations) and utility value (M ES = .013, SE = .002 for achievement; M ES = .051, SE = .006 for aspirations), due to the positive and significant effects of SES on these constructs.

3.5. The interaction effects of expectancy by value

In the present study two critical expectancy by value interactions were included: self-concept by intrinsic value and self-concept by utility value. The multiplicative effects between self-concept and utility value on mathematics achievement and educational aspirations were both statistically significant (M ES = -.055, SE = .013 for achievement; M ES = -.069, SE = .015 for aspiration). The simple-slopes (Preacher, Rucker, & Hayes, 2007) are illustrated in Figure 2 and show the effects of mathematics self-concept on achievement at the mean of value of utility and at one standard deviation below and above this mean value. Self-concept had a positive effect on 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, indicating that utility value could compensate to some extent for lower self-concept in the prediction of achievement. 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 latent interaction between self-concept and utility value was also evident for educational aspiration (see Figure 3), showing that when utility value is low, self-concept contributes more positively to aspiration, whereas the effects of self-concept on achievement at different levels of utility value were much stronger than those on aspiration, resulting from self-concept being a dominant predictor of achievement. The self-concept by intrinsic value interaction was not statistically significant for either outcome.

4. Discussion

The purpose of this study was to examine the relationship between gender, SES, and mathematics achievement and educational aspiration, mediated by expectancy and value. Also, we tested the interaction effect of expectancy and value on these educational outcomes by using large representative samples of Hong Kong Year 8 students from three waves of TIMSS data (1999, 2003, and 2007). Our findings extend previous research on the relations between background variables and educational outcomes, particularly in relation to the mediating role of expectancy and value. Our

findings demonstrate a significant expectancy by value interaction, although the nature of this interaction differs from the synergistic interaction posited in the original EVT.

4.1. Expectancy and value predicting outcome variables

In line with prior research on the effects of expectancy and value (e.g., Eccles & Wigfield, 2002) and in supporting of our expectations, the results reveal that self-concept had an effect on achievement that was as strong and positive as the effect of utility value on educational aspiration, when expectancy and value beliefs were simultaneously included in the predictive model. However, in contrast to a rich body of empirical research (Eccles, 1993; Dennissen, Zarret and Eccles, 2007; Durik, Vida and Eccles, 2006) the unique effects of intrinsic value were not statistically significant. A possible explanation is that as a function of intrinsic value being highly correlated with self-concept (M r = .772, SE = .019), intrinsic value did not have its own substantial positive effect on outcome variables when expectancy and value were considered together.

4.2. Background factors predicting outcome variables

Supporting our expectations about gender effects, boys tended to have high self-concept and intrinsic value in mathematics; this is consistent with the results in Western countries (Eccles et al., 1993; Marsh & Yeung, 1998; Wigfield et al., 1997; Marsh et al., 2013). The results match gender stereotypes in mathematics, with boys having more positive competence beliefs and affect than girls. However, in line with a longitudinal study from first to twelfth grade, conducted by (Jacobs, et al., 2002), no gender difference on utility value was found in this study. It is worth noting that when controlling for self-concept and value, small and negative direct effects of gender on achievement and aspiration were found consistently, indicating that if girls and boys had the same level of self-concept and value, girls tended to have higher mathematics achievement and educational aspirations. Nonetheless, this negative direct effect on achievement was counter-balanced by the corresponding positive indirect effect, which suggests boys tend on average to have higher self-concepts, which have a strong and positive relationship with achievement. For aspiration, the direct effect was only partially counter-balanced by the corresponding indirect effect (via self-concept and utility value). In total, there were no gender differences on mathematics achievement, while educational aspiration favored girls to a small extent. This finding is in line with the substantial change in gender difference on

educational attainment, with the numbers of girls enrolled in university study (e.g. health science and social science) exceeding that of boys (Census Statistics Department, 2007)

Consistent with previous findings (e.g. Eccles, 1993), SES was a positive predictor of expectancy and value, which indicates that students who lived in a high SES family were likely to have more positive self-concept and intrinsic and utility value. However, inconsistent with a cross-cultural study conducted by (Marsh, Hau, & Artelt, 2006), based on PISA, our results found that utility value was more strongly associated with SES than with self-concept. Further, in line with previous research (Halle, et al., 1997; Hampden-Thompson & Johnston, 2006), SES had moderate and positive effect on mathematics achievement and educational aspiration. In addition, the effects of SES on achievement and aspiration were also significantly mediated by self-concept and utility value. The relations between gender, SES, and outcome variables were not mediated through intrinsic value, resulting from intrinsic value losing positively predictive power on achievement and aspiration.

In summary, gender differences on self-concept and interest in mathematics favored boys, while students living in high socioeconomic status families had more positive motivation, particularly in utility value. There was no statistical gender difference in mathematics achievement, but girls had slightly higher educational aspirations, while students in high SES families tended to attain high scores in mathematics and to have high educational aspirations. These results are consistent with expectations.

4.3. Expectancy by value interaction

Recent developments in structural equation modeling promise to help us detect expectancy by value interaction, which was a cornerstone of the original EVT model (Atkinson, 1957) but which is neglected in the modern model (Eccles et al., 1983), based on observational data. Inconsistent with our expectations, significant main and latent interaction effects suggest that higher self-concept, higher utility value and their interaction, all contributed to higher mathematics achievement and educational aspiration. In interpreting the latent interaction on aspiration, one factor should be borne in mind; all expectancy and value constructs were mathematics-specific, while the aspiration construct was composed of a single and domain-general indicator related to educational attainment. Given that expectancy and value were highly domain specific, a student who had high verbal self-concept or

interest might contribute to his or her high aspiration in educational attainment. Likewise, and inconsistent with our expectations, interaction patterns relating intrinsic value by self-concept were not significant. This may be due to the high correlation between these two constructs (M r = .772, SE = .019).

4.3. Implications

The current research on both gender and socioeconomic status has been useful in highlighting important inequalities in Hong Kong education. Despite strong evidence for there being no gender differences in mathematics achievement, the pattern continues, of gender stereotypic differences in favor of boys in students' perceptions of competence and interest in mathematics. It was evident however, that girls were favored in educational aspiration, which potentially leads to advantage in college attainment. Previous research in a Hong Kong context has revealed that the reason for gender differences favoring girls in educational aspiration might be the underrepresentation of boys in school achievement (Francis, Luk-Fong, & Skelton, 2012). Our findings have potentially important implications for policy, practical applications and interventions that explore the elimination of inequalities in gender and socioeconomic status.

First, teachers must be sufficiently skilled to simultaneously enhance students' expectancy and value, particularly for girls. Second, educators and parents may need to pay more attention to underrepresentation in boys' performance in school (e.g., boys' underachievement, more behavior problems), which has a detrimental influence on boys' educational aspirations. Third, 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 TIMSS2007 cohort.

4.4. Generalizability and limitations

It is important to note that the three cohorts in the present study relate to a period in which the educational context in Hong Kong was changing substantially. For example, the new mathematics education and a series of new education policies were implemented by the handover of sovereignty from the UK to China in 1997, and the instruments used to measure key constructs differed across

cohorts (e.g., there was a single intrinsic value indicator in TIMSS 2003 but multiple indicators in

TIMSS 1999). However, the results were relatively consistent, indicating the internal validity of the

results (see Shadish, Cook and Campbell, 2002). This provides evidence for strong generalizability,

given the substantial changes made to the educational system in this historic period.

　　Nevertheless, the generalizability of these results has limitations. First, it is not clear how these

results would generalize to Western countries or to other Asian countries. Although Hong Kong is

seen to be influenced greatly by Western culture, it is more appropriately described as neo-Confucian

(Lee, 1996), where parents and family are the basis of the cultural upbringing of Chinese children as

emphasized by Confucian heritage (Phillipson & Phillipson, 2007). Chiu & Xihua (2008) have

addressed how the effects of family characteristics on children's mathematics achievement are

stronger in individualistic and more affluent countries. Second, in the present study, a narrow SES

construct was applied, leading to some potential limitations. For example, this SES construct did not

include other characteristics typically considered to be part of SES, such as parents' income and

occupation. Third, in the present study, only one single item on the scale of educational aspiration was

a general rather than domain specific aspiration. Given that both expectancy and value are highly

domain specific (Eccles et al., 1993), there is a need for items to assess students' intention of studying

a specified subject after school and taking up a specified-domain career (e.g., "I would like to work in

a career involving [mathematics] after [secondary school]"). Thus, this study should be replicated

with an enriched set of outcome variables to test the EVT in a Hong Kong context. Fourth, the results

regarding expectancy by value interaction does not support a synergistic relationship of classical EVT.

Further research is needed to evaluate its cross-cultural generalizability in mathematics and other

disciplines (e.g., science and English) through international comparative study. Finally, to evaluate the

causal ordering of the EVT constructs in relation to short- and long-term outcomes, what is needed is

a longitudinal data set for future research.

5. Conclusion

　　In sum, the results of the present study add to previous evidence indicating that expectancy

(mathematics self-concept) is a stronger predictor of mathematics achievement than mathematics

utility value is of educational aspiration, when both are considered simultaneously. As a function of

the close association between self-concept and intrinsic value, however, intrinsic value was not a

significant predictor, considered together with self-concept and utility value. Further, we found that

there was no gender difference in mathematics achievement, even though girls were favored in

educational aspiration. In addition, family socioeconomic status had positive effects on mathematics

achievement and educational aspiration, and these effects were partially mediated by expectancy and

value. In terms of expectancy by value interaction, significant main and interaction between self-

concept and utility effects suggests that higher self-concept, higher utility value, and their interaction,

all contribute to higher educational outcomes. The pattern of the effects investigated was generally

consistent across all three waves of TIMSS data, despite the substantial changes in the education

system that occurred in Hong Kong among the TIMSS cohorts.

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Table

Table 1.
Path Coefficients and Standard Errors From the Hypothesized Model

Effect of Background factors on Motivation factors

	SES on MSC	SES on MIV	SES on MUV
1999	0.083*(0.026)	0.085* (0.024)	0.172*(0.024)
2003	0.074*(0.021)	0.038 (0.021)	0.143*(0.024)
2007	0.123*(0.032)	0.080*(0.034)	0.174*(0.032)
Mean (S.E.)	0.087*(0.015)	0.062*(0.014)	0.161*(0.015)

	gender on MSC	gender on MIV	gender on MUV
1999	0.144*(0.037)	0.187*(0.031)	0.025 (0.019)
2003	0.235*(0.021)	0.137*(0.019)	0.043*(0.021)
2007	0.235*(0.020)	0.111*(0.024)	0.035 (0.021)
Mean (S.E.)	0.223*(0.013)	0.138*(0.013)	0.034 (0.018)

Direct effect on Mathematics Achievement (ACH)

	MSC on ACH	MIV on ACH	MUV on ACH	SES on ACH	Gender on ACH
1999	0.454*(0.070)	0.029 (0.066)	0.083*(0.031)	0.175*(0.041)	-0.090*(0.028)
2003	0.433*(0.044)	-0.016 (0.053)	0.098*(0.023)	0.164*(0.032)	-0.116*(0.027)
2007	0.316*(0.043)	0.101*(0.044)	0.074*(0.032)	0.201*(0.038)	-0.141*(0.034)
Mean (S.E.)	0.386*(0.028)	0.048 (0.030)	0.088*(0.016)	0.178*(0.021)	-0.113*(0.017)

Direct effect on Aspiration (ASP)

	MSC on ASP	MIV on ASP	MUV on ASP	SES on ASP	Gender on ASP
1999	0.211*(0.041)	-0.094 (0.059)	0.313*(0.027)	0.290*(0.025)	-0.163*(0.023)
2003	0.112*(0.046)	-0.082 (0.053)	0.362*(0.030)	0.290*(0.024)	-0.099*(0.019)
2007	0.113*(0.044)	-0.028 (0.039)	0.260*(0.029)	0.334*(0.029)	-0.136*(0.024)
Mean (S.E.)	0.168*(0.027)	-0.055 (0.029)	0.311*(0.017)	0.302*(0.015)	-0.128*(0.013)

Indirect effect on ACH

	SES via MSC	SES via MIV	SES via MUV
1999	0.038*(0.013)	0.002 (0.007)	0.014*(0.006)
2003	0.032*(0.010)	-0.001 (0.002)	0.014*(0.004)
2007	0.039*(0.011)	0.008 (0.005)	0.013*(0.003)
Mean (S.E.)	0.036*(0.006)	0.001 (0.002)	0.013*(0.002)

	gender via MSC	gender via MIV	gender via MUV
1999	0.052*(0.019)	0.005 (0.012)	0.001 (0.002)
2003	0.102*(0.014)	-0.002 (0.007)	0.004*(0.002)
2007	0.074*(0.012)	0.011 (0.005)	0.003 (0.003)
Mean (S.E.)	0.080*(0.008)	0.006 (0.004)	0.003 (0.002)

Indirect effect on ASP

	SES via MSC	SES via MIV	SES via MUV

gender via MSC / gender via MIV / gender via MUV

	gender via MSC	gender via MIV	gender via MUV
1999	0.018*(0.009)	-0.008 (0.005)	0.054*(0.009)
2003	0.008*(0.004)	-0.003 (0.003)	0.052*(0.010)
2007	0.014*(0.007)	-0.002 (0.003)	0.045*(0.010)
Mean (S.E.)	0.012*(0.003)	-0.003 (0.002)	0.051*(0.006)

	gender via MSC	gender via MIV	gender via MUV
1999	0.024*(0.009)	-0.018 (0.011)	0.008 (0.006)
2003	0.026*(0.011)	-0.011 (0.007)	0.016*(0.008)
2007	0.027*(0.011)	-0.003 (0.004)	0.009 (0.006)
Mean (S.E.)	0.029*(0.007)	-0.006 (0.004)	0.010*(0.004)

Total effect of background factors on ACH and ASP

	SES on ACH	gender on ACH	SES on ASP	gender on ASP
1999	0.229*(0.043)	-0.032 (0.043)	0.354*(0.020)	-0.149*(0.022)
2003	0.209*(0.025)	-0.012 (0.055)	0.347*(0.019)	-0.068*(0.040)
2007	0.261*(0.040)	0.053 (0.034)	0.391*(0.021)	-0.103*(0.021)
Mean (S.E.)	0.225*(0.019)	0.014 (0.024)	0.364*(0.012)	-0.114*(0.014)

Latent interaction effect ACH and ASP

	MSCxMIV on ACH	MSCxMIV on ASP	MSCxMUV on ACH	MSCxMUV on ASP
1999	0.012 (0.017)	-0.001 (0.014)	-0.044*(0.020)	-0.084*(0.023)
2003	0.001 (0.023)	0.021 (0.024)	-0.061*(0.024)	-0.035 (0.030)
2007	-0.001 (0.021)	0.054*(0.020)	-0.062*(0.022)	-0.074*(0.024)
Mean (S.E.)	0.005 (0.011)	0.018 (0.010)	-0.055*(0.013)	-0.069*(0.015)

Note. t value > 1.96, * p < .05; MSC = mathematics self-concept; MIV = mathematics intrinsic value; MUV = mathematics utility value; SES = socioeconomic status; ACH = mathematics achievement; ASP = educational aspiration.
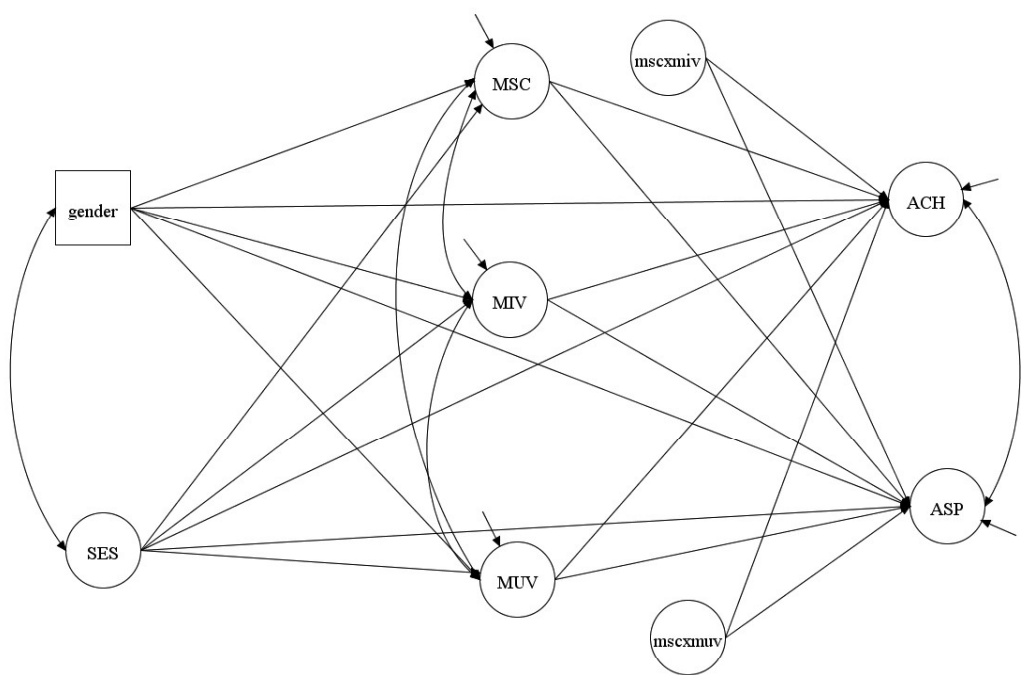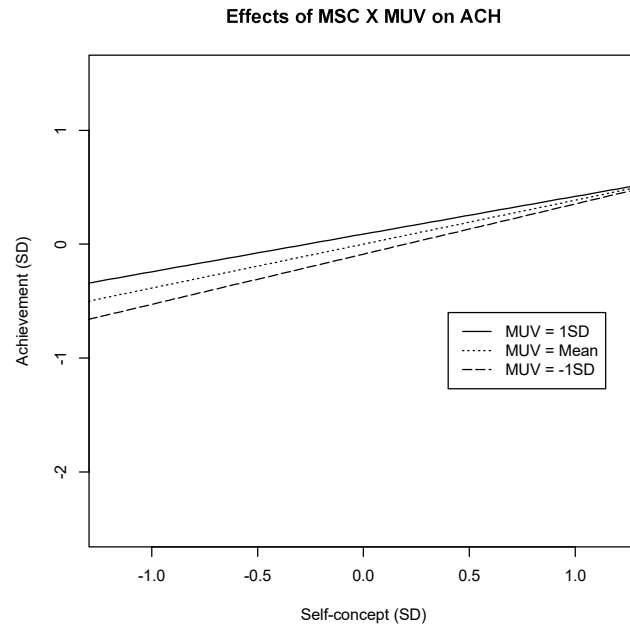
Figure

Figure 1. The hypothesized model

Effects of MSC X MUV on ACH

Figure 2. Simple-slopes showing the effects of the latent-interaction variables (self-concept by utility value) on mathematics achievement
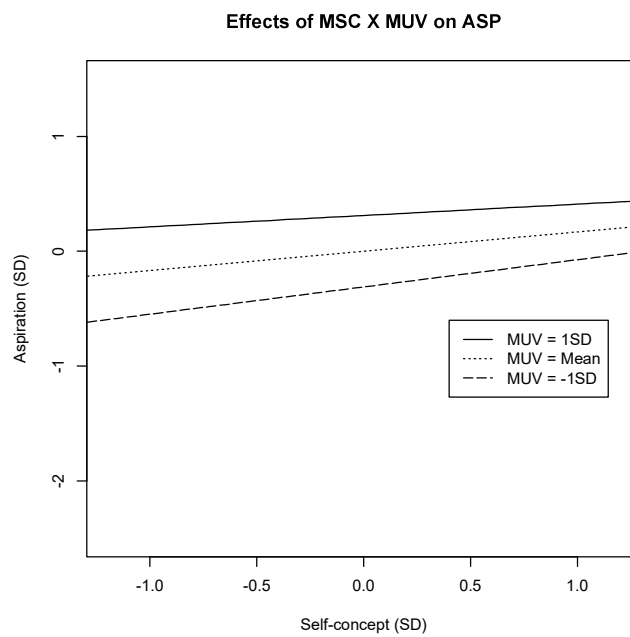
Effects of MSC X MUV on ASP

Figure 3. Simple-slopes showing the effects of the latent-interaction variables (self-concept by utility value) on aspiration

e-component

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