Predicting Career Aspirations and University Majors from Academic Ability and Self-concept: A Longitudinal Applications of the Internal-External Frame Of Reference Model

Philip Parker, Gabriel Nagy, Ulrich Trautwein, & Oliver Lüdtke

Career aspirations and University majors are particularly important for research exploring gender differences in science, technology, engineering, and mathematics (STEM) fields as they provide the basis from which individual enter these occupational arenas and/or obtains access to higher degrees and thus more advanced positions in these fields. In 1976 (see also Sells, 1980), Sells indicated that mathematics in school is a critical filter where differences in math achievement accounted for gender differences in training and careers in STEM across the life span. Math as a critical filter suggests that math ability is associated with entry into many university majors, with poor achievement and/or failure to undertake mathematics advanced courses effectively barring individuals from many prestigious careers (Ma & Johnson, 2008; Shapka, Domene, & Keating, 2006). This has important implications for females as empirical research findings suggest women are less likely to undertake advanced course selection in mathematics (eg. Nagy, Garrett, Trautwein, Cortina, Baumert, & Eccles, 2008) and generally have lower math achievement scores (eg. Wigfield, Battle, Keller, & Eccles, 2002). Interestingly, however, studies on gifted populations of students indicate that fewer females enter the physical sciences, mathematics, and technology professions despite having the requisite ability (Eccles & Harold, 1992). This suggests achievement alone is insufficient to explain gender differences in these fields.

Many theories of career and academic choice highlight the importance of psychological factors over and above achievement including math self-concept, interest, and values that provide information on the appraised appropriateness of a particular achievement-related choice (with respect to other potential choices) (e.g. Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Eccles, 1994; Marsh & Yeung 1997; Wigfield et al., 2002). Furthermore research and theory suggest that focusing solely on predictors associated with a single domain provides a limiting perspective on predicting and explaining gendered career-relevant outcomes. The internal/external frame of reference model proposed by Marsh (1986, 1990b) explicitly focuses on such intra-individual cross-domain comparison with recent research indicating associations between math and verbal domains are useful for predicting achievement-related choices and aspirations (Marsh & Yeung, 1997; Nagy et al., 2006, 2008; Parker et al., in press a). As yet, this model has rarely been applied to career-relevant variables such as university majors and aspirations, despite its potential relevance.

Math and Gendered Differences in STEM fields.

The role of mathematics as a critical filter to later prestigious careers developed as a hypothesis to explain gender differences in the enrollment of women in STEM university majors (Sell, 1976). While this hypothesis originally developed in relation to a broad set of STEM fields, there has been considerable progress in recent years in closing the gender gap in some domains (Brotman & Moore, 2008). Largely, this progress has occurred within biological and medical sciences where more females than males undertake and/or aspire to careers in these areas (Eccles, 1994; Keeves & Kotte, 1992; Nagy et al., 2006). This suggests that the traditional idea of gender differences in STEM is misleading, rather considerable gender gaps continue to exist in some sciences fields, most prominently the physical sciences, mathematics, engineering, and technology (hereafter PME) (Brotman & Moore, 2008; Camp, Gilleland, Pearson, Putten, 2009; Chinn, 1999; Eccles, 1994; Eccles & Harold, 1992; Jones, Howe, & Rua, 2000; Rosenbloom, Ash, Dupont, Coder, 2008).

Much research has found that math achievement is critical in predicting a variety of career path relevant variables and is a potential mechanism to explain the continued gender differences in PME fields (eg., Ma & Johnson, 2008). Indeed, both multination and longitudinal research has suggested an important link between school math ability and achievement related-choices both in school and in career paths (Nagy et al., 2008; Parker et al., in press a; Schoon, 2001; Schoon et al., 2007). Models of achievement related choices, however, have suggested that the role of math achievement is insufficient to explain gender differences in PME fields and have indicated the importance of psychological factors such as self-concept, self-efficacy, or interest as central determinates of important of career relevant choices and aspirations (Bandura et al., 2001; Eccles, 1994). In relation to self-concept, considerable support is now present in the literature to suggest its importance in both academic and career-relevant choices and outcomes and its importance as a predictor over and above achievement (e.g. Camp et al., 2009; Marsh & Yeung, 1997; Nagy et al., 2008; Parker et al., in press a; Schoon et al., 2007).

Self-concept Factors Associated with Academic and Career Choice

Importantly, these results generally support theoretical models which suggest that stereotypical self-evaluations including self-concept mediate the role of ability in predicting various achievement-related choices (Bandura et al., 2001; Eccles, 1994; Marsh & Yeung, 1997). Indeed, Bandura et al.'s (2001) review of the literature suggests that when ability and achievement are controlled for stereotypical self-evaluations continue to be strong predictors of number of career relevant choices and aspirations. Stereotypical self-evaluations, in part, suggest that there are important gender differences in achievement relevant self-perceptions over and above gender differences in achievement. Indeed, research suggests that domain specific academic self-beliefs factors not only differ by gender but also continues to strongly predict achievement-related choices after controlling for achievement (e.g. Nagy et al., 2006, 2008; Parker et al., in press a).

These gender differences suggest that males consistently report higher levels of mathematics self-concept, while females report higher levels of verbal self-concept factors (for a review see Marsh, 1990a). Research and theory suggest that gender differences in self factors not only incorporate differences in achievement but also stereotypical self-evaluations informed by the individuals social context (socialization, parental expectations, cultural climate, stereotypical gender roles); all of which are thought to be influential in explaining gender differences in career paths (see Eccles, 1994; Rosenbloom et al., 2008; Shapka et al., 2008; Wigfield et al., 2002). These models also emphasis the importance of taking into account self-beliefs in multiple domains rather than just in mathematics. This is consistent with Eccles (1994) who suggested the limiting picture that emerges from only considering the influences of math relevant variables when exploring achievement-related choices. As such, self-concept is not just an important predictor of career relevant choices but provides a framework for predicting and interpreting gender difference in career-relevant outcomes like PME aspirations and university majors.

Internal/External Frame of Reference Model

Marsh's (1986, 1990b) I/E model provides a potential framework for the association between achievement and academic self-concept factors across multiple domains in predicting career relevant variables. The model also has the potential for framing gender difference in such outcomes as it focuses on domains known to have stable gender differences – verbal (favoring females) and math (favoring males) (Marsh, 1990a). The model focuses on self-concept, which is hypothesized to be multi-dimensional and hierarchical arranged construct consisting of a number of self-perceptions relating to socially relevant domains of interest

(Marsh & Hau, 2004; Shalveson, Hubner, & Stanton, 1976). While, this model has traditionally been used to explain self-concept formation (Marsh, 1989, 1990b), more recent research has begun to use the model as a framework for explaining academic choices (Marsh & Yeung, 1997; Nagy et al., 2006, 2008; Parker et al., in press b). The basic I/E model was developed to account for several paradoxical self-concept findings including: a) the moderate correlation between achievement measures and general academic self-concept; b) the observations that math and verbal self-concepts are only weakly related despite math and verbal achievement being moderately to strongly related; and c) the negative correlations between achievement in one domain and self-concept in another domain (Marsh, 1990b).

In relation to these empirical finding, Marsh (1986, 1990b; see also Parker et al., in press b) suggested that domain specific academic self-beliefs general emerge as the result of two competing frames of reference. The moderate to strong correlation between domain specific self-concept and achievement within a subject area can be explained by an external frame of reference where students evaluate their ability in a subject in reference to their peers. In such cases, class tests and other comparative achievement indicators provide information on which individuals can make self-relevant judgments. The low correlation between math and verbal self-concept however, is explained by an internal frame of reference where individuals' achievement in different subject areas are compared relative to each other - -a so-call ipsitive effect (Marsh, 1990b). That is that individuals tend to compare their performance in multiple domains where better performance in one domain (e.g. math) results in a higher self-concept for that field than for other fields (e.g. English) even if objective performance in both fields is relatively low. Alternatively, higher math performance would be expected to be associated with lower English self-concept even if performance in English is comparatively high (Marsh & Hau, 2004).

Thus, it would be expected on the basis of I/E model that higher mathematic achievement would have a negative relationship with verbal self-concept and vice-versa. This model and the expected relationships between achievement and self-concept have received wide spread cross-cultural support (Marsh & Hau, 2004). Importantly, this model can both incorporate gender differences in math and verbal self-concept (Marsh, 1990a), and differences in stereotypical self-evaluations with gender contributing to differences in self-concept even after achievement differences are controlled for (Nagy et al., 2008; see Figure 1).

While the model has consistent empirical support (see Marsh & Hau, 2004), it has been applied to achievement-related choices in only a few cases. The results of these studies however, confirm I/E predictions suggesting that a) high levels of math self-concept predict math relevant achievement-related decisions such as taking or aspiring to an advanced course in mathematics, b) higher English self-concept is negatively related to taking such courses even after controlling for achievement in both fields, and c) the introduction of self-concept as a predictor reduces the importance of achievement in predicting achievement-related choices (Marsh & Yeung, 2001; Nagy et al., 2006, 2008; Parker et al., in press a). Consistent with not only the I/E model but other models of achievement-related choice (eg. Bandura et al., 2001; Eccles, 1994), these results suggest that the effect of achievement on choice may be mediated by self beliefs and evaluations. Taken together, these results indicate the potential relevance of the I/E model in predicting career-relevant choices and outcomes particularly in relation to the high math relevant PME fields.

A Research Example

While the I/E model is well supported in academic settings (Marsh & Hau, 2004) and has been found to predict academic relevant choices such as advanced course selection (Marsh & Yeung, 1997; Nagy et al., 2006, 2008), the model has rarely been used to predict career-relevant variables. Furthermore, research using this model to predict outcomes has typically been cross-sectional in nature. This is particularly relevant in the current research where the transition from school to a career path introduces a number of new influences that may lessen the importance of I/E processes formed in school. Thus we provide a research example that resolve some of this limitations in the current research and illustrate many of the concepts discussed above. In particular we explore whether the I/E model predicts career aspirations concurrently in school but also whether this model has a longitudinal influence on career variables after school. To further is research and provide an empirical example of the concepts under consideration we explore the role of the I/E model in predicting university majors two years later in a sample of German young poeple.

This was done through several steps. First, gender differences were explored in domain specific achievement and self-concept as well as in university majors. Second, gender differences in university majors were explored. The current research went beyond typical distinctions between science and non-science fields given the increasing participation of women in biological and medical sciences, as well as the continued gap when it comes to mathematics, physics, and engineering fields (see Parket et al., in press a). The current research considered four groups consisting of a) physical sciences, math and engineering, b) life, biological and medical sciences, c) law and business, and d) humanities that closely map groupings found in the ISCO-88 occupational coding scheme (Elias, 1997). Third, the research explored the I/E model via structural equation modeling, to see if the relationships between gender, self-concept, and achievement expected by the I/E framework were present in this data set. Finally, gender and verbal and Math self-concept and achievement were used to predict career aspirations at school and later university majors where several specific hypotheses were made: a) that high levels of math achievement and self-concept would predict aspirations toward and university majors in PME over other fields, b) that English achievement and self-concept would predict aspirations toward and university majors in other fields over PME, c) that the introduction of self-concept would result in achievement becoming a less important predictor, d) that these processes will predict not only concurrent career aspirations but would also predict longitudinal university majors two years later. It was expected that the incorporation of gender differences in math and English self-concept factors with these I/E predictions would provide a useful frame for exploring gender differences in aspirations and university majors, particularly in reference to PME fields.

Method

Participants

The current research utilized data from the ongoing project *Transformation of the Secondary School System and Academic Careers* (TOSCA) conducted in Germany at the Max Planck institute of Human Development and the University of Tübingen. The data for this particular project comes from the second cohort of this project which begun in 2006 from schools which represent the university or college track in Germany (Gymnasium). The second time wave was completed in 2008 when participants where in university. In total 1881 participants completed measures of self-concept and math and English achievement, as well as their career aspirations, at Time 1 and reported their university majors at Time 2. Participants average age at Time 1 was 19.76 (*SD* = 1.12). The sample was weighted toward females (58 percent). Such a bias has been suggested in previous research with German university track students that these samples tend to reflect more selective populations of males than females (see Nagy et al., 2006). The 1881 participants came from a much larger database of 5030 young adults. These participants where chosen as they had provided information at Time 2 indicating that they were at university or other tertiary colleges and were undertaking majors in professional fields.

Materials

Achievement. The mathematics achievement test administered was taken from the Third International Mathematics and Science Study (TIMSS; e.g., Baumert, Bos, & Lehmann, 2000). Reliability estimates indicating good internal consistency (α = .88; formula by Rost, 1996). English achievement was assessed using a shortened research version of the Test of English as a Foreign Language (TOEFL), as used in the Institutional Testing Program. The instrument comprises three components (listening comprehension, structure and written expression, reading comprehension). Reliability of the achievement measure was good (α = .95).

Self-Concept. Math and English self-concept were measured using the German version (Schwanzer, Trautwein, Lüdtke, & Sydow, 2005) of the SDQ III (Marsh & O'Niel, 1984). The SDQ III is a multidimensional self-concept instrument for late adolescents and young adults and includes a number of domain specific factors based on the Shavelson, Hubner, & Stanton (1976) model. Previous research with the SDQ instruments indicates its excellent construct validity and reliability in German (Marsh, Trautwein, Lüdke, Köller, & Baumert, 2006; Schwanzer et al., 2005). From the 17 scales in the SDQ III (German), only the math self-concept factor (eg. *I was always good in mathematics*) and the English (eg. *I am good at English*) self-concept factor added in recent versions of the German SDQ III were used. Participants responded to each item on a 4-point (agree-disagree) response scale. Internal consistency for the current sample was .91 for math self-concept and .93 for English self-concept.

Career Aspirations and University Majors. At Time 1, participants were asked to give qualitative response to their long-term career aspirations. At Time 2, participants were asked to report on their university major. In both cases these qualitative responses were given a code based on the ISCO 88 system (Elias, 1997). Only participants with an ISCO 88 code for career aspirations or university majors which placed them within the major occupational group of professionals where included in the sample. These participants where then coded into four groups broadly reflecting the ISCO 88 profession sub-groups and previous research and theory. The groups included: a) math, physics, and engineering (hereafter PME), b) life, biological, and medical science (hereafter biological/medical sciences), c) humanities and social sciences (hereafter humanities), d) law, economics, and business (hereafter law/business).

Analysis

Analysis consisted of several phases. First, exploration of gender differences in Math and English achievement and self-concept, and in career aspirations and realized university majors were explored. Second, career aspiration at school and university major group profiles on the I/E achievement and self-concept variables were explored using a set of univariate ANOVAs. In addition the relationship between self-concept and achievement were explored in relation to I/E model using Structural Equation Modeling (SEM). Finally, multinomial logit models were used in Mplus to explore the role of math and English achievement and self-concept in predicting career aspirations and later university majors. All variables observed (achievement scores) and latent (self-concept) factors were standardized to the same scale so that odd ratio's could be directly compared. Full-information-maximum-likelihood estimation was implemented for the small amount of missing data (<5 percent) relating to achievement and self-concept factors.

Results and Discussion

Gender Differences, Career Aspirations and University Majors

Table 1 illustrates the gender differences in career aspirations present at Time 1. The gender difference observed in previous research (e.g., OECD, 2011) was present in this sample with only seven percent of females indicating a desire to work in PME fields. In contrast, PME was the most popular career aspiration for males with 45 percent indicating that they aspired to work in this field. Humanities represented the opposing gender pattern to PME with 56 percent of females aspiring to careers in the humanities, but only 26 percent of males. A greater percentage of females than males aspired to work in the fields of biological/medical sciences thought the difference was moderate (Males 15 percent; Females 21 percent). Finally, law/business was the least gender typed aspirations (Males 14 percent; Females 16 percent). For university majors, though smaller, gender differences generally followed the same pattern as in career aspirations[1]. While the increased participation of women in many professional fields, particularly biological/medical sciences, was observed, the continued and considerable gender differences in PME favoring males (and humanities favoring females) was apparent (Wigfield et al., 2002). These results, including the higher rate of women taking on humanities majors, are consistent with trends in the US (Bowen et al., 2010) and internationally (OECD, 2011). Many hypotheses have been developed to explain such gender difference. One more recent hypothesis is that the difference is due, at least in part, to differences in achievement and/or academic self-concept profiles (e.g., Eccles, 1994; Lubinski & Benbow, 2006).

Gender Differences, Career Aspirations, University Majors, and the I/E Model

Achievement and Self-concept Profiles by Gender. Analysis then moved to explore the predictors of career aspirations and university majors in terms of gender differences and mean profiles across aspiration and university major groups. Gender differences in the central constructs generally followed those expected for mathematics but expected patterns were less

[1] The match between career aspirations at Time 1 and university majors at Time 2 was explored (see Table 2). Importantly career aspirations in school were a strong predictor of what young adults would go on to study in university two years later (Kappa = .62). Important for the current research's focus on PME, aspirations and majors in this field were the most closely related over time with 90 percent of young adults who aspired to PME careers studying university majors in these fields at university. The humanities also displayed a close match between career aspirations and university majors. Aspiring to biological/medical sciences was the least predictive with only 56 percent who aspired to this field undertaking university majors in this area two years later. The strong predictive effect of aspirations predicting actual university majors is strongly consistent with the Wisconsin model of educational and status attainment.

apparent for English (see Table 3). Males tended to achieve higher scores on the math achievement test (*d* = -.46, p<.001) and were higher on math self-concept (*d* =-.35, p<.001). Males also recorded higher scores on the English language test (*d*= -.31, p<.001) but there was no significant difference on English self-concept despite the achievement differences (*d* = .06, ns).[2] These results however, need to be understood in the context of the German education system. As Nagy et al. (2008) note gymnasium (university track) entry is more selective for boys than it is for girls. Put simply, gymnasium schools draw female students from a wider band of achievement than they do males. This is supported when exploring the PISA results for 2003 (for math) and 2009 (for reading). The PISA reports which consist of a random sample of the total German secondary school population rather than just those in the university track schools show that females outperform males in verbal domains (PISA, 2004). For all secondary school students there is a gender difference in mathematics favoring males in mathematics but, while significant, it is smaller than the difference noted in this chapter (PISA, 2010).

Achievement and Self-concept Profiles by College Major. Standardized mean profiles on I/E factors were also explored across the four academic fields on aspirations and university majors (see Figure 2 and 3). As expected, individuals who aspired to and who undertook majors in PME fields had the highest math achievement and self-concept but comparatively lower levels of English achievement and the lowest levels of English self-concept. Humanities displayed the opposite pattern with among the lowest levels of math achievement and self-concept for both aspiration and university major groups. Interestingly, the biological/medical sciences groups displayed relatively high levels of both math and English achievement and self-concept, with the highest English achievement scores and the second

[2] The lack of gender differences favoring females may reflect the nature of the sample where German university track school have a smaller and more selective male population (Nagy et al., 2006).

highest mathematics scores. Univariate ANOVAs indicated all I/E predictors were significantly different across groups ($p < .001$). Importantly, in relation to career aspirations, group membership predicted considerable variance in math relevant predictors (Math achievement $R^2 = .12$; Math self-concept $R^2 = .18$), though group membership also explained statistically significant amounts of variance in English variables (English achievement $R^2 = .02$; English self-concept $R^2 = .02$). In relation to university majors, group membership explained large amounts of variance in Math variables (Math achievement $R^2 = .11$; Math self-concept $R^2 = .24$) but also statistically significant levels in English variables (English achievement $R^2 = .01$; English self-concept $R^2 = .05$).

Mean profiles on math and English achievement and self-concept, indicated that the PME group was the only group to consistently display math achievement scores and self-concept levels higher than that for English achievement and self-concept for both career aspirations at school and later university majors. Most other groups displayed the opposite pattern with higher levels of English achievement and self-concept than corresponding math factors. However, those who aspired to and studied biological/medical sciences displayed relatively similar levels of both math and English self-concept and achievement. This profile suggest a continuum of career choice ranging from fields with high math and relatively lower verbal influences in PME, to fields with a balance of math and verbal in the biological and medical sciences, through to those outcomes that are more dominated by verbal influences in law and business and the humanities. The degree to which these math dominated university majors are associated with gender, achievement, and academic self-concept was then explored.

I/E Predictors of Career Aspirations and University Majors[3]

Two stepwise multinomial logit models were run, one for Time 1 I/E factors predicting career aspirations at school and one for Time 1 I/E factors predicting Time 2 university majors[i] (see Table 3). Each multinomial logit model consisted of a series of steps. Step 1 included gender as the sole predictor. Step 2 included gender and math and English achievement. Finally, Step 3 included all predictors including math and English self-concept. In all models the PME group was used as the reference group. Results are presented in odds ratios.

The first stepwise model used gender and I/E predictors at Time 1 to predict career aspirations in school. In the first step gender was found to be a significant predictor of career aspirations, with results indicating females were significantly more likely to aspire to be in any field other than in PME, particularly in relation to humanities (*or* = 3.66, $p < .001$). The second step indicated that higher math achievement decreased the odds that an individual would be in an aspiration group other than PME, while English achievement increased the odds an individual would be in a group other than PME with the exception of biological/medical sciences (*or* = 1.14, *ns*). In the final step, math and English self-concept were introduced into the model, resulting in a considerable decrease in the predictive effects

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[3] An SEM model was used to explore the validity of the I/E model in the current sample. This model explored the role of gender on English and Math Achievement and self-concept and the relationship between achievement measures and domain specific academic self-concept . This model provided an adequate to excellent fit to the data (Chi-Square = 468, DF = 38, RMSEA = .08, CFI = .97) and supported the hypotheses drawn from I/E and self-concept theory. In particular, gender predicted both achievement and self-concept. Gender difference in achievement favored males (males coded 0, females coded 1) in both math ($\beta = -.24$, $p < .001$) and English ($\beta = -.12$, $p < .001$). Controlling for gender differences in achievement, gender predicted self-concept in expected patterns with males higher in math self-concept ($\beta = -.11$, $p< .001$) and females, and despite lower levels of achievement, were higher in English self-concept ($\beta = .06$, $p < .001$). In relation to the associations between achievement and self-concept, findings strongly supported I/E predictions in the following three ways. First, math achievement was a strong predictor of math self-concept ($\beta = .61$, $p < .001$), while English achievement was a strong predictor of English self-concept ($\beta = .65$, $p < .001$). Second, math achievement was a moderate negative predictor of English self-concept $\beta = -.21$), $p < .001$, and English achievement was a statistically significant negative predictor of math self-concept ($\beta = -.14$, $p < .001$). Finally, the association between math and English self-concept controlling for achievement paths was moderate and negative ($r = -.21$, $p < .001$).

of achievement. Indeed, the effect of achievement predicting career aspirations was weakened to non-significant levels in all cases with the exception of math achievement predicting aspirations in PME over biological/ medical sciences (*or* = .50, $p < .001$). Importantly the results for the self-concept factors closely followed I/E prediction where it was found that higher math self-concept increased the odds that an individual would aspire to a career in PME over humanities (*or* = .26, $p < .001$) and business/law (*or* = .44, $p < .001$). In contrast, higher English self-concept increased the odds a person would have career aspirations in biological/medical science (*or* = 2.11, $p < .001$), law/business (*or* = 1.78, $p < .001$), and humanities (*or* = 1.60, $p < .001$) than in PME.

Using the same strategy as for career aspirations at school, I/E factors at school were used to longitudinally predict university majors two years later. Gender was found to be a strong predictor of university majors with results ranging from females being one and a half times more likely (Step 1: *or* = 1.69, Step 3: *or* = 1.55) to study biological/medical sciences than PME to females being almost two and a half times more likely to study humanities (Step 1: *or* = 2.69, Step 3: *or* = 2.46) than PME. In step 2, achievement tests were observed to be a predictor of all university major groups with high math achievement decreasing the odds that an individual would study biological/medical sciences (*or* = .45, $p < .05$), humanities (*or* = .36, $p < .001$), or law/business (*or* = .77, $p < .001$) over PME. In contrast, English achievement increased the odds an individual would undertake study in any one of these fields over PME. In the final step, domain specific self-concept was introduced into the model. Again the introduction of self-concept considerably reduced the effects of achievement with only math achievement predicting PME university majors over biological/medical science majors being the only remaining significant effect (*or* = .68, $p < .001$). Results for self-concept again matched I/E predictions suggesting that high English self-concept significantly increased the odds that an individual would go on to study in a field other than PME, particularly in relation to biological/medical sciences (*or* = 2.04, p < .001) and humanities (*or* = 1.79, p < .001) but also in law/business (*or* = 1.62, p < .01). High math self-concept was associated with a much greater likelihood that individuals would study PME over any other field, particularly for the humanities (*or* = .27, p < .001), but also in biological and medical sciences (*or* = .58, p < .001) and law/business, (*or* = .52, p < .001).

With the relationships between constructs following patters expected on the basis of the I/E model, multinomial logit models likewise supported hypotheses drawn from the I/E model. These multinomial models suggested that math factors increased the odds that an individual would have aspirations in and study PME fields. Likewise, English achievement and self-concept decreased these odds.

The findings also supported several central models of career-relevant choices where self-beliefs are expected to mediate the relationship between achievement (and other gendered socio-cultural influences) and outcomes (Bandura et al., 2001; Eccles, 1994; Marsh & Yeung, 1997), as the introduction of self-concept generally resulted in achievement becoming a non-significant predictor. This suggests that stereotypical self-evaluations play a central role in achievement-related aspirations and choices. From an I/E perspective the importance of self-concept as a predictor is due to self-concept containing information not only from an external frame-of-reference, tied closely to achievement scores, but also an internal frame-of-reference which consists of information drawn from individuals internal comparison of their performance across a range of subject areas (Marsh, 1986, 1990b; Marsh & Yeung, 1997). Furthermore, Eccles (1994) suggests that self-evaluation factors contain information about socialization, gender roles, and parental expectations, all of which impact individual's views about the nature of certain fields and whether these fields are more or less appropriate for the individual when compared to other fields. This is also consistent with Bandura et al. (2001)

who emphasis the importance of self-beliefs as a product of a range of achievement and socio-cultural factors and as central determinates of a range of career outcomes.

For gender the results suggest two things. First, it was stereotypical self-evaluations that appeared to be more important and accounted for more of the effect of gender than achievement. Second, even when controlling for achievement and self-concept, gender still had a strong and significant effect on university major choice. This indicates that the effect of gender on university major selection is more complicated than simply differences in achievement and self-beliefs but likely includes task value, gender socialization, and other psychological and contextual factors (see Eccles, 1994).

Constrained Multinomial Logit Models

A final set of analyses were run in which parameters were constrained to be equal in predicting aspirations and university majors in fields other than PME. This provided an opportunity to explore whether odds ratios for I/E factors predicting non-PME appraisals and university majors differed across biological/medical sciences, humanities, and business/law. Results suggested that constraining parameters across groups resulted in a significantly worse fitting model than one in which all parameters were free to vary for both career aspirations (loglikelihood (14) = 184, $p < .001$) and university majors (loglikelihood (14) = 339, $p < .001$). Follow-up tests indicated that all groups differed from the PME reference group in significantly different ways (see Table 4). We used a series of line graphs of standardized multinomial regression coefficients to explore these differential effects. These graphs suggest that math achievement and English self-concept were the most important factors in predicting biological/medical sciences aspirations and university majors group membership over PME group membership (see Figure 5 and 6). In contrast, math self-concept (and to a lesser degree English self-concept) but not achievement, were more important for predicting law/business and humanities membership. Interestingly, math self-concept was a more important predictor for the humanities, while English self-concept was more important for law/business. These profiles were relatively consistent for both career aspiration and the university major outcomes.

These results reveal that the math and English achievement and self-concept factors distinguished biological/medical sciences, humanities, and law/business from PME in significantly different ways. In particular, it appeared that lower math achievement and higher English self-concept were key factors in choosing biological and medical sciences over PME. Interestingly, this suggests that the mediating role of self-concept maybe less important for this group where math achievement remained a significant predictor of both concurrent aspirations at school and longitudinal university majors. Likewise, the relative importance of math or English variables as predictors differed across groups. English self-concept was relatively more important for predicting aspirations and entry into law/business over PME, while math self-concept was more important for the humanities. This suggests that both of the central predictions of this paper drawn from the I/E model – the mediating role of self-concept and the ipsative processes between math and English variables – predicted career-relevant variables in different ways depending on the fields of interest.

General Implications

These finding of this research example expresses the limitations of considering math achievement alone as a critical filter into the physical sciences for women. Indeed, math achievement was reduced to a non-significant significant predictor of PME aspirations and university in all cases but the biological/medical sciences when academic self-concept was introduced. It is important to note, however, that math self-concept was the strongest predictor in the current research indicating it maybe a more critical filter to PME careers than math achievement. While math self-concept was clearly an important factor, the current results indicate that considering variables in a single domain may not be sufficient in providing an explanation of differences in career paths such as why individual choose PME over biological/medical sciences. Such a model has important substantive and applied implications for explaining gender differences in career aspirations and university majors. This is particularly the case when the results are placed in the context of gender difference in self-concept.

Implication for Policy and Practice

Eccles (1994) states that gender differences in career paths can reflect legitimate decisions by females to choose occupational arenas which best reflect their interests, attitudes, and values. Indeed, Eccles (1994, p. 605) indicates that female choices not to enter male dominated fields are both 'reasonable and predictable'. Importantly, however such choices have implications for PME fields and suggest that society as a whole may suffers from the loss of women's talent and perspectives when they do not enter fields such as PME (Eccles, 1994).

Importantly, this chapter points to the importance of self-perceptions at school as a target for intervention and policy. First, the self-concept factors used in this research were formed in school and predicted achievement-related choices both concurrently, for career aspirations at school, and longitudinally, for university majors. Second, these self-concept factors were stronger predictors of both appraisals and university majors than achievement. Finally, SEM results indicated that gender contributes to differences in self-perceptions, with males higher on math self-concept and females higher on English self-concept, after controlling for achievement differences (see footnote 3). Taken together, these findings indicates that stereotypical self-evaluations formed in school (both low math and high English) may be a barrier to females entering PME fields.

As such effects to improve female participation in PME arenas should consider the importance of academic self-perceptions and the importance of school experiences in forming these perceptions. Importantly, given the positive effect of high math self-concept on PME aspirations and university majors and the parallel negative effect of high English self-concept, any program aiming to increase PME participation must carefully target programs by acknowledging a multidimensional approach to academic self-concept (O'Mara, Marsh, Craven, & Debus, 2006) and acknowledge the integrated effect that multiple academic (and indeed other life) domains outside of mathematics have on young adults achievement-related choices (Eccles, 1994). Indeed, highlighted by this research is the idea that individuals use profiles across a range of domains rather than strengths in a particular area in order to make achievement related choices (see Eccles, 1994). As such, useful strategies may include increasing the salience of strengths in mathematical skills, knowledge, and abilities of females who are gifted in these areas and by suggesting that such individual may be more suited to careers in PME fields rather than in traditional gender stereotyped occupations.

In some cases the introduction of self-concept reduced the direct effect of gender on aspirations and university majors suggesting that academic self-concept may be one important mechanism that explains gender differences in gendered aspirations and university majors. However, one of the most interesting findings was that there were still considerable gender differences after controlling for achievement and self-concept. This suggests that other gender relevant choice mechanisms are in play. Eccles (1994) achievement related choices model suggests some additional pathways that were not explored here but are likely to help account for the remaining gender difference effect. First, math and verbal self-concept can largely be categorized in the work of Eccles as expectancies of success (see Nagengast et al., 2011). The effect of such expectations on achievement related choice like university majors are hypothesized in Eccles' model to be moderated by task values. Significant gender differences have also been observed in such task values (Chow & Salmela-Aro, 2011) and thus such constructs are likely to be of interest to future research. Another mechanism that may help explain gender differences in aspirations and college majors that was not studied here is the role of gender socialization (Eccles, 1994). Taken together, gender differences in aspirations and college majors appear to be the result of a multi-causal system. Thus, while research progresses by identifying and studying components of this system, like the research example used here, policy and practice is likely to benefit most from considering a broader picture, synthesizing research from a number of different perspectives.

Conclusions

Using Marsh's (1986,1990b) Internal/External frame of reference model we found that high levels of math achievement and self-concept and low levels of English achievement and self-concept predicted career aspirations in PME fields over other professional fields at school and PME university majors longitudinally two years later, with the opposite pattern predicting entry into other fields such as the humanities and law and business. Furthermore, supporting a number of recent models of career-relevant outcomes, the introduction of self-concept factor reduced the importance of achievement as a predictor indicating the importance of stereotypical self-evaluations that are in part formed by ipsitive processes between math and verbal academic domains (Marsh, 1989) and the socio-cultural context of the individual (Eccles, 1994). The results suggest that those seeking to increase female participation in PME fields should consider the importance of stereotypical self-evaluations formed in school, and that programs should acknowledge both a multi-dimensional approach to academic self-concept and the importance of profiles across multiple domains in achievement-related choices.

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Table 1

Gender Differences in Self-Concept and Achievement

	Males		Females		Cohen's D	
	Mean	SD	Mean	SD		
Math Self-concept	2.84	.81	2.55	.83	-.35***	
English Self-Concept	2.92	0.82	2.87	0.86	-0.06	
English Achievement^	.17	.99	-.13	.98	-.31***	
Math Achievement^	.19	.91	-.22	.87	-.46***	
	Percentage Male		Percentage Female		Odds Ratio: Males	
	Aspire	UM	Aspire	UM	Aspire	UM
PME	44.8	47.4	7.0	17.0	10.8	4.4
Biology/Medical	15.0	10.3	21.3	12.7	0.7	0.8
Humanities	26.0	16.8	55.7	44.2	0.3	0.3
Law/Business	14.2	25.5	16.0	26.1	0.9	1.0

Note. ^English and Math tests scores are standardized. Aspire = Career aspirations, UM = University majors. *p < .05, **p < .01, ***p < .001. Aspire = Career Aspiration groups. UM = university major groups.

Table 2

Time 1Career Aspirations and Time 2 University Majors

Career Aspirations Percentage	University Majors Percentage			
	PMES	BMS	Law/Business	Humanities
PMES	**90.0**	4.7	2.1	3.2
BMS	17.2	**55.6**	13.6	13.6
Law	15.6	5.6	**68.2**	10.6
Hum	6.0	2.2	9.0	**82.8**

Note. Chi-Square (9) = 1068, p < .001. Kappa = .62

Table 3

Multinomial Logit Odds Ratios for Career Aspirations

	Step 1			Step 2			Step 3		
	Bio	Law	Hum	Bio	Law	Hum	Bio	Law	Hum
					Career Aspirations				
Gender (F=1)	2.66***	3.66***	2.98***	2.40***	3.42***	3.00***	2.46***	3.06***	3.47***
Math Test				.37***	.36***	.64***	.50***	1.11	.86
English Test				1.14	1.41**	1.48**	.73	.99	.92
Math SC							.70	.44***	.26***
English SC							2.11***	1.78**	1.60*
					University Majors				
Gender (F=1)	1.69***	2.69***	1.84***	1.56***	2.52***	1.90***	1.55***	1.88***	2.42***
Math Test				.45***	.36***	.76**	.68***	1.15	.83
English Test				1.33***	1.73***	1.64***	.86	1.19	1.08
Math SC							.58***	.52***	.27***
English SC							2.04***	1.62***	1.79***

Note. Reference group is PME. S1 = Step 1 with only gender as a predictor. S2 = Step 2 with gender and achievement measures as predictors. S3 = Step 3 with gender, achievement, and self-concept as predictors. *p < .05, **p < .01, ***p < .001. SC = self-concept. All predictors standardized.

Table 4

Loglikelihood Difference Test of Constrained Multinomial Logit Models verses Free Model

	Loglikelihood Difference Test		
Constrained Parameters	*df*	Career Aspirations	University Majors
All Parameters Constrained	14	184 ***	342***
Biological/Medical Sciences and Law/Business Constrained	9	99 ***	147***
Humanities and Biological/Medical Sciences Constrained	9	169***	321***
Humanities and Law/Business Constrained	9	167***	321***

Note. Loglikelihood difference test produces values on a chi-squared distribution. Significant value indicates constraining paths to be equal significantly reduces the fit of the model compared to a model in which all parameters are free to vary. ***p < .001.

Figure 1. The Internal/External model.

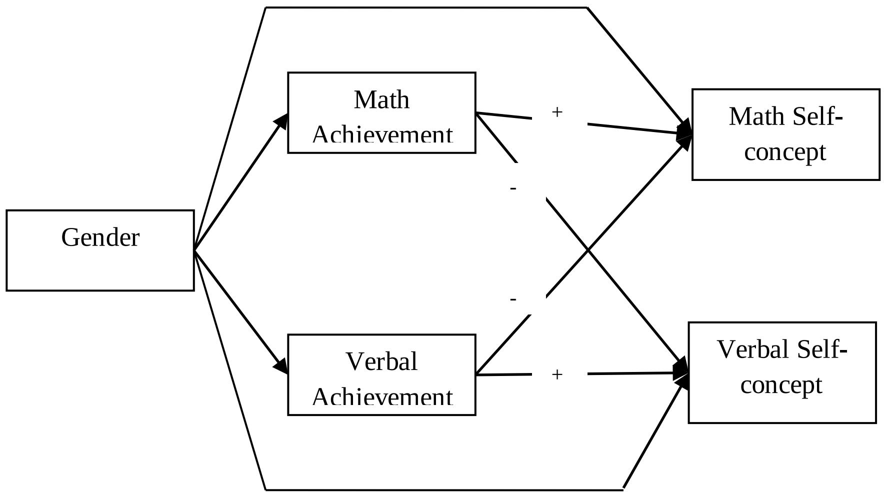
Figure 2. Extended Internal/External model.

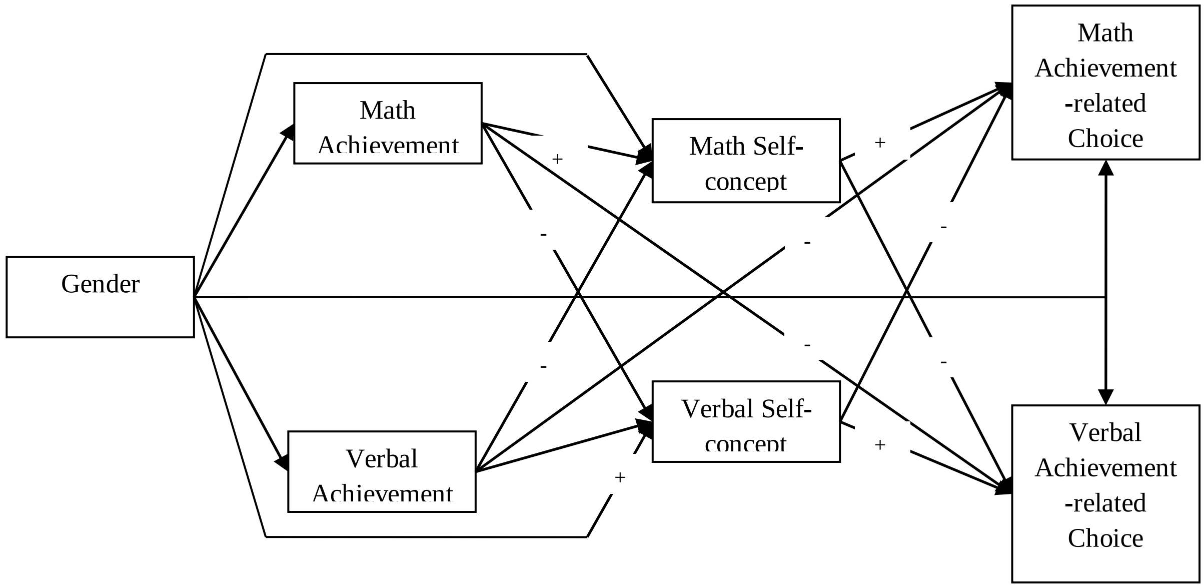
Figure 3. I/E factor profiles for career aspiration groups.

Figure 4. I/E factor profiles for career major groups.

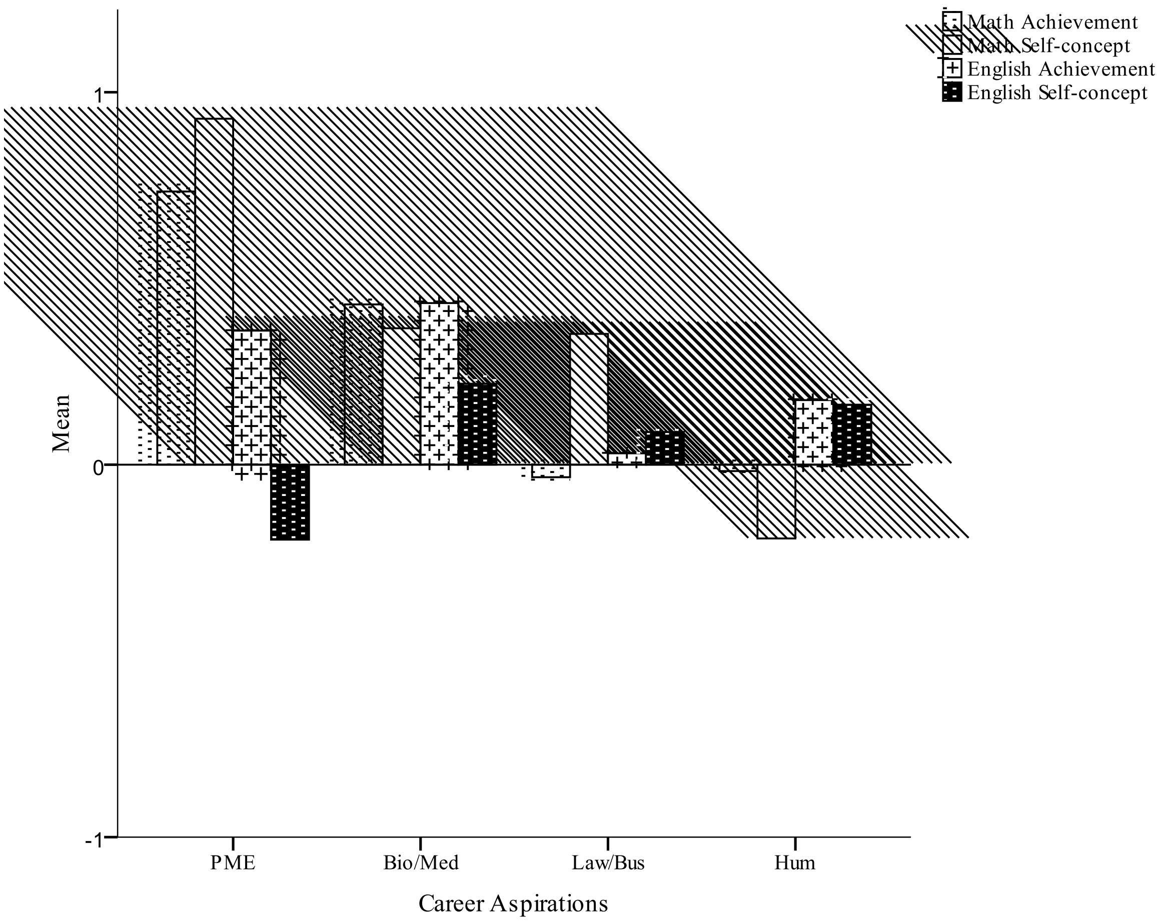
Figure 5. Profile of standardized multinomial regression weights for career aspiration groups.

Figure 6. Profile of standardized multinomial regression weights for university major groups.

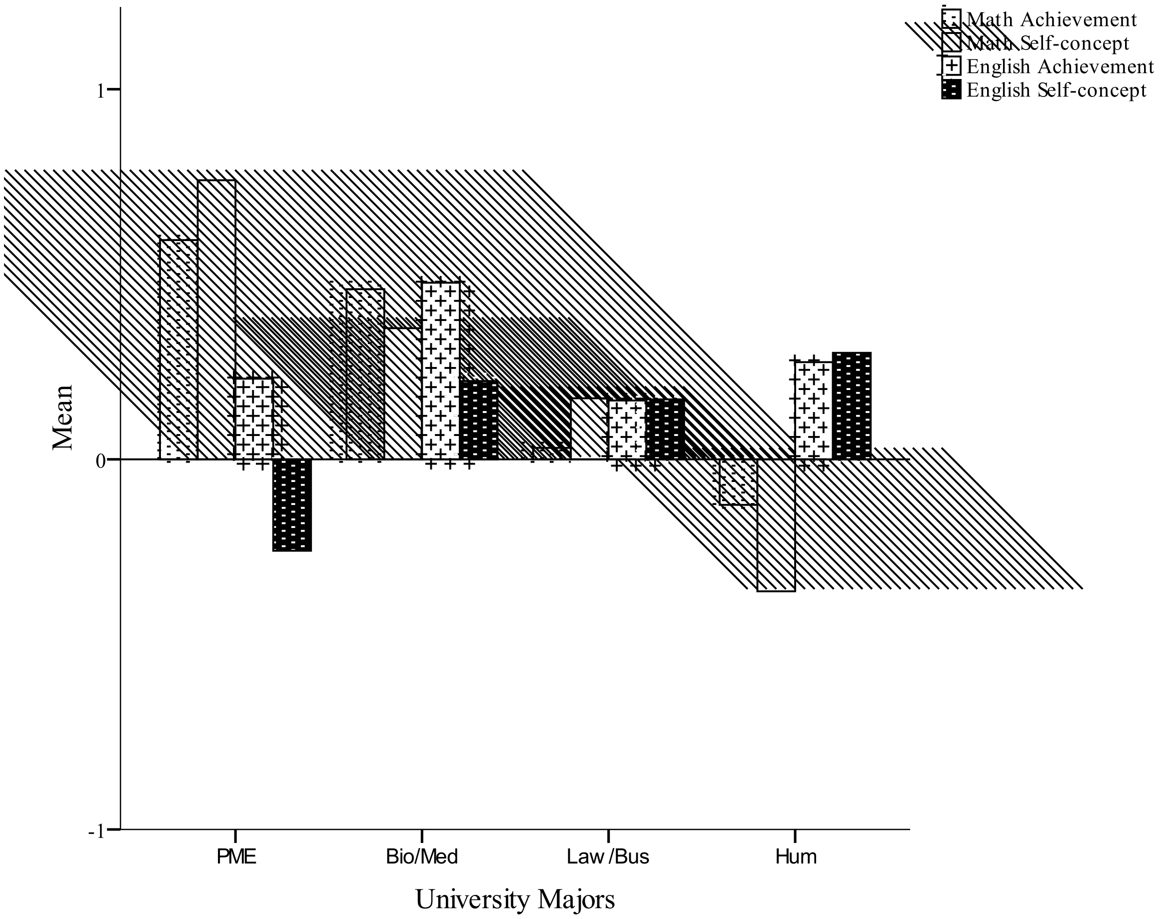


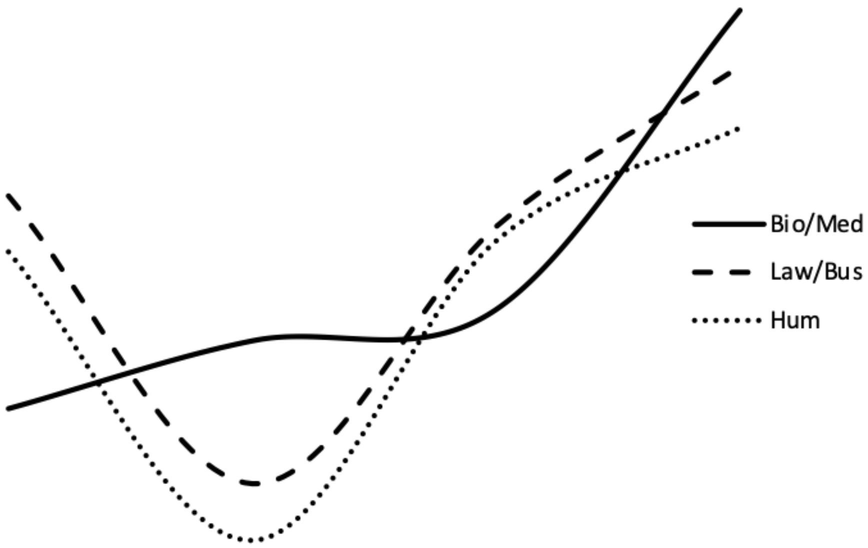


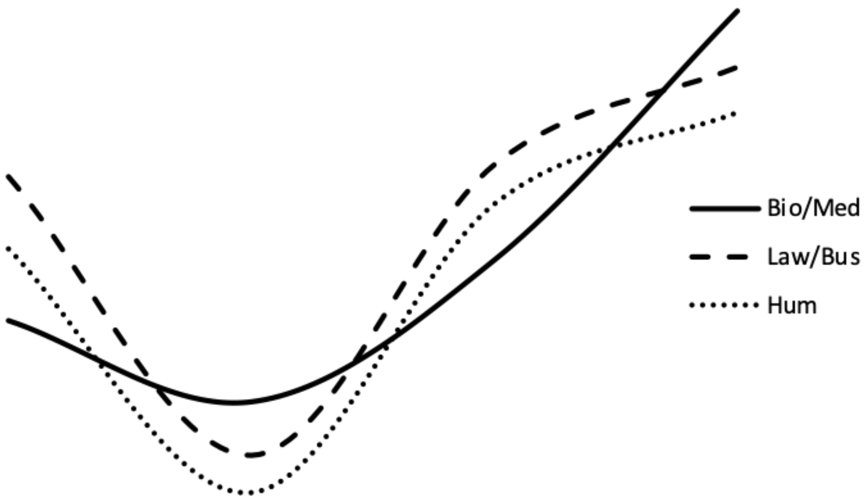
Gender
Math Achievement
Verbal Achievement
Math Self-concept
Verbal Self-concept
Math Achievement -related Choice
Verbal Achievement -related Choice
+
-
-
+
+
-
-
-
-
+



Math Achievement
Math Self-concept
English Achievement
English Self-concept
1
0
-1
Mean
PME
Bio/Med
Law/Bus
Hum
Career Aspirations


Math Achievement
Math Self-concept
English Achievement
English Self-concept
1
0
-1
Mean
PME
Bio/Med
Law/Bus
Hum
University Majors


Bio/Med
Law/Bus
Hum


Bio/Med
Law/Bus
Hum