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The System of Academic Task Values: The Development of Cross-Domain Comparisons of Values and College Major Choice

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Abstract

This study synthesizes theories of achievement motivation to better understand the development of academic task values in high school students and their relation to college major selection. We utilize longitudinal structural equation modeling to understand how grades relate to task values, how task values across domains relate to one another over time, and how the system of task values relates to college major choice. In our sample of 1279 high students from Michigan, we find evidence that task value for math negatively relates to task value for English and vice versa. We also find that task value for math and physical science positively relate to the math intensiveness of selected college majors, whereas English and biology task value negatively relate to math intensiveness of majors. Gender differences in college major selection are mediated by differences in task values. Our findings have implications for theories of achievement motivation and motivational interventions.

Public Significance Statement

This study advances the idea that academic values across multiple subjects in high school are predictive of college major selection. This study suggests that gender differences in selecting math intensive majors can be explained by gender differences in values across the subjects of math, English, and science.

Keywords: Subjective task-values, cross-domain comparisons, academic motivation, college major selection, expectancy-value, dimensional comparisons

The System of Academic Task Values:

The Development of Cross-Domain Comparisons of Values and College Major Choice

"The reality of choice in human action presents one major opportunity for the study of values. Values are operative when an individual selects one line of thought or action rather than another." (Kluckholn, 1951)

As adolescents near high school graduation, the choice of selecting a college major becomes a pivotal life choice. College major selection offers students a rare opportunity to exhibit autonomy in their academic lives, and the major they select will likely influence future career options. From a plethora of choices, how do students decide what major to select? Many theories of motivation posit that values motivate choices and initiate action. For example, situated expectancy-value theory (SEVT) posits that, in addition to achievement and ability beliefs, academic task values that students hold for various academic subjects will substantially influence their choices (Eccles, 1994). Values have also been conceptualized to be hierarchical and integrate into value systems (Eccles, 1994; Locke, 1991; Rokeach, 1973; Williams, 1979), and ultimately there is an "economy of values," for no student has the resources or time to make all possible choices (Kluckhohn, 1951). Hierarchies of values refer to mental systems in which people rank a value one above the other according to its perceived importance. However, much of the recent literature on values and academic choices has ignored these hierarchies and value systems, focusing only on a value for a single academic domain, its relation to achievement, its development, and its association with academic behavior (e.g., Musu-Gillette et al., 2015;

Simpkins et al., 2006). Sparse attention has been given to academic value comparisons across domains (e.g., math, English, science), where value for one subject may positively or negatively influence value for another subject. In this study, we investigate the development of academic values in high school, including how achievement in different domains relate to academic values across domains, how value for one domain relates to value for another domain, and how the collective system of values influence college major choice.

The Nature of Values and Situated Expectancy-Value Theory

Before discussing the relationship between values and behavior, let us define what we mean by values. We begin with the definition of Milton Rokeach (1973), as stated in his seminal work on human values, who defined a value "as an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (p. 5). He elaborated that these values form a value system concerning preferable modes of conduct along a continuum of relative importance. From this perspective, values are considered antecedents to behavioral choices, and a major goal of values research has been to relate individual differences in value priorities to different behaviors (Schwartz, 2013).

Influenced by the seminal works of Rokeach (1973), the situated expectancy-value theory (SEVT) of achievement performance and choice conceptualized subjective task value as the quality of the task that contributes to the increasing or decreasing probability than an individual will select it (Eccles & Wigfield, 2020). Subjective task value is thus determined by the fit between personal values and characteristics of the task itself (Eccles & Wigfield, 1995). These subjective task qualities include (1) attainment value, or the value an activity has in fulfilling one's identity or self-image; (2) interest value, which refers to the expected enjoyment in task engagement; (3) utility value, how useful the task is in fulfilling various short and long-term goals; and (4) the personal cost of engaging in the activity. SEVT scholars were explicit in highlighting that the hierarchy of task values matter more in academic choices than individual values (Eccles, 2005). In the context of deciding one's college major, academic task values help define which majors are likely to be most interesting, useful, and in line with one's identity.

Strikingly, despite many theories stating that multiple values compete within a person to influence behavior, most of the modern empirical research on academic values has focused on value for a single academic domain. Even within expectancy-value theory, which emphasizes the hierarchical nature of activity choice based on multiple values (see Eccles, 2005), analyses have consistently focused on value for a single academic domain to understand academic choices, such as course selection or college major (e.g., Musu-Gillette et al., 2015; Simpkins et al., 2006). This incongruence between applied research and theory is problematic. Schwartz (2013) criticized this method of focusing on relations between single values and behavior, claiming that such research leads to a piecemeal accumulation of information about values that is not productive to the development of coherent theories. According to Schwartz, without a broad theory of the relations between values, it is possible that omitted values are just as important to understanding behavior as the single value included. Lastly, single-value approaches neglect the assumption that behavior is not guided by the priority given to a single value, rather through tradeoffs among competing values related to the behavior under consideration. College major selection provides an opportunity to study value conflicts, as students must pick from numerous options and multiple values may influence this choice. It is in the presence of conflict that values are likely to be activated and to be used as guiding principles (Schwartz, 2013). We agree with Schwartz that values may positively or negatively relate to one another. This implies the existence of dynamic relations between values. To date, the empirical work investigating how subjective academic task values influence one another has been minimal. However, recent developments in self-concept literature provide insights in how to consider the relations between multiple academic domains.

Cross-Domain Comparisons of Achievement

Seminal work on self-concept of ability by Shavelson, Huber, and Stanton (1976) highlighted the evaluative nature of ability beliefs, whereby evaluations of one's ability likely take into account relative standards. Building directly on Shavelson and colleagues work, Marsh (1986) elaborated on how these evaluations operate theoretically and empirically in the internal/external frame of reference model (I/E model), which describes the effects of students' math and verbal achievements on their math and verbal self-concepts of ability. According to the I/E model, math and verbal self-concepts of ability form based on social (external) and dimensional (internal) comparisons (Marsh, 1986; Möller et al., 2009). Because of social comparisons, where students compare their achievements with their classmates' achievements in the same domain, there should be positive effects of student achievement in one domain on their math self-concept in the same domain. Because of internal dimensional comparisons, where students compare their math and verbal achievements with each other, there should be negative effects of students' math achievement on their verbal self-concept. Thus, dimensional comparisons between math and verbal achievement lead to an increased self-concept in the domain where students show the higher achievement, but to a decreased self-concept in the domain where students show the lower achievement (Marsh, 1986; Möller & Marsh, 2013). For example, a student with high math achievement and low English achievement will likely have a much higher math self-concept of ability than a student with the same math achievement but even higher English achievement.

To date, more than 100 studies have found support for the assumptions of the I/E model (Möller et al., 2020). The joint effects of social and dimensional comparisons have been shown in student samples of different ages, gender distribution, and countries, although the dimensional comparison effects were stronger for older students (Wan et al., 2021). They were shown for different operationalizations of achievement (Möller et al., 2020) and self-concept (Wolff et al., 2019; Wolff et al., 2018a). In addition, the assumed joint effects of social and dimensional comparisons on students' domain-specific self-concepts have replicated for other methodological approaches, including experimental studies (e.g., Müller-Kalthoff et al., 2017), introspective studies (e.g., Möller & Husemann, 2006), and longitudinal studies (e.g., Wolff at al., 2018b). A recent meta-analysis of 103 studies found a significant decline in the relations between students' math and language motivational beliefs over time (Wan et al., 2021). In other words, dimension comparisons became more salient and important in the development of academic self-concept over the yearsUltimately, the relative ranking of self-concepts across domains (e.g., math and English) has also been found to predict academic choices, including college major selection (Umarji et al., 2018).

Whereas the classic I/E model only refers to math and verbal achievements and self-concepts, more recent studies have also tested a generalized I/E model, which includes different combination of school subjects (Möller et al., 2016). The theoretical rationale of this model stems from dimensional comparison theory (DCT; Möller & Marsh, 2013), which has extended the core deliberations of the I/E model concerning dimensional comparisons into a more general comparison theory. DCT assumes that dimensional comparisons take place between different school subjects, whereby the strength and direction of the dimensional comparison effects is assumed to depend on the “similarity” of the subjects compared with each other (see also Marsh et al., 2014). Whereas dimensional comparisons between achievement in two dissimilar subjects, such as math and English, should lead to negative (i.e., contrasting) dimensional comparison effects, these effects might decrease and even turn into positive (i.e., assimilating) dimensional comparison effects if achievement in two similar subjects, such as math and physics, are compared with each other. Previous research has found empirical support for these assumptions (e.g., Arens et al., 2020; Jansen et al., 2015; Marsh et al., 2014; Wolff et al., 2019). However, assimilative dimensional comparison effects have been found within the math/science domain rather than in the verbal domain, and especially between math, physics, and chemistry. When biology was considered, dimensional comparison effects within the math/science domain were usually contrastive (e.g., Jansen et al., 2015; Marsh et al., 2015; see also Möller et al., 2020).

Cross-Domain Comparisons of Academic Task Values

Based on findings from diary studies (Möller & Husemann, 2006) and studies testing the I/E model for different kinds of outcome variables (Möller et al., 2016, for an overview), DCT assumes that dimensional comparisons are not limited to subject-specific achievement and subject-specific self-concepts, but that dimensional comparisons should also relate to other self-related constructs (Möller & Marsh, 2013; Wigfield et al., 2020). Thus, subject-specific academic values should also develop based on dimensional comparisons of achievement and relative value for one domain versus another. Given the applicability of the generalized I/E model to examine dimensional comparisons between a number of different constructs, this framework may help guide our investigation into the development of academic task values and academic choices. The literature on this topic is limited, but a few studies have examined the development of academic emotions and values with consideration to dimensional comparisons. In a study testing the I/E model and academic enjoyment (which is empirically similar to interest), math achievement was associated with lower verbal enjoyment and verbal achievement was associated with lower math enjoyment (Goetz et al., 2008). However, this study did not investigate the effects of enjoyment on future academic choices. In a cross-cultural study of German and American students (Nagy et al., 2008), German students' English intrinsic value (i.e., interest value) decreased the likelihood of taking advanced math courses in high school. However, this finding did not replicate on the sample of American students. Nonetheless, the authors suggested that the results indicate that students may engage in intraindividual cross-domain comparisons when making academic choices. Gaspard and colleagues (2018), using a sample of German adolescents in grades five to twelve, compared dimensional comparisons of expectancies (i.e., self-concept of ability) and task-value across five academic domains (German, English, biology, physics, and math) with achievement, finding stronger evidence for dimensional comparisons in self-concept than values. We seek to add to what these studies have found by considering development of values over time and associations with other academic choices.

Gender Differences in Task Values and College Major Selection

One of the most important aspects of studying values is the association between values and behavior. Central to this literature, especially from an expectancy-value perspective, are the gender differences that have been observed in academic task values and educational choices. Regarding task values in adolescence, relative to males, females typically report lower task value and enjoyment for math (Frenzel et al., 2007; Simpkins et al., 2006), lower task value for science (Simpkins et al., 2006), but higher task value for literacy (Durik et al., 2006; Jacobs et al., 2002). Consequently, as males in adolescence typically report higher task value in math, they select more math intensive majors than females (Musu-Gillette et al., 2015). However, as previously stated, these studies and most others have relied on a single-domain-value approach. They operate under the hypothesis that math intensive college majors are understood by studying math task value alone. Although such an approach may be useful for explaining group level mean differences in college major choice, it may not be appropriate for explaining the within-person process of selecting one's college major. At the person level, individuals are selecting from several alternatives. According to Eccles and Wigfield's perspective on SEVT, people make such choices by comparing the subjective task values across the relevant options. For example, Eccles (1994, p. 591) argued that "it is assumed that the decision to take advanced math is based primarily on variables related to math. We explicitly reject this assumption, arguing instead that it is essential to understand the psychological meaning of the roads taken, as well as the roads not taken, if we are to understand the dynamics leading to the differences in women's and men's achievement related choices." Thus, in order to better understand college major selection as a central achievement related choice, the inclusion of multiple domains of academic values is necessary for studying both individual and group differences in achievement related choices. In one of the few studies to do so, Chow, Eccles, and Salmela-Aro (2012) used latent profiles to identify that males were more likely than females to be in profiles with high math and high science task value, and thus more likely to aspire for physical science and IT-related professions. Another study of Australian youth found that reading achievement had a negative effect on selecting a STEM major, which they explained was mediated by decreased value for math (Guo et al., 2015). They also found gender differences, where males were more likely to select STEM majors.

The Present Study

In the present study, we address some of the gaps in the literature on the development of academic task values and college major choice. Our study considers a more comprehensive model of academic values development and how these values specifically relate to the amount of math required by college major. In line with the theoretical assumptions of SEVT and DCT, we investigate the extent to which achievement in multiple domains relates to academic task values in these subjects, the ways in which task values develop across the high school years, and ultimately, the extent to which hierarchies across multiple values relate to the choice of math intensive college majors. We also consider how gender relates to the development of these task values and educational choices. We focus on academic values during high school because adolescence is an integral period for the development of motivational beliefs about achievement-related domains according to EVT (Eccles & Wigfield, 2020). During these years, students begin to substantially differentiate their academic values across domains (Wan et al., 2021, 2022). Moreover, adolescence is an integral time for identity formation, including the development of academic and occupational identities (Erikson, 1968). Developmental career choice models suggest that with increasing mental maturity, adolescents are better able to engage in self-exploration and identification of preferred and accessible career options relative to younger children (e.g., Gottfredson, 1981, 2002; Super, 1990). As high school students begin making important academic decisions, including high school course selection that may prepare them for college majors of interest (Gaspard et al., 2020), understanding how academic values develop in high school and relate to their college major is important. We focus on task values for math, English, biology, and chemistry in tenth and twelfth grade, as well as the math intensiveness of chosen college majors. The four research questions (RQs) we seek to answer are the following:

RQ1: To what extent does achievement in each domain relate to subjective task values across these domains?

RQ2: To what extent do task values early in high school (i.e., 10th grade) relate to task values towards the end of high school (i.e., 12th grade)?

RQ3: To what extent does task value in each domain predict the math intensiveness of college major?

RQ4: To what extent does gender relate to task values and the math intensiveness of college major?

For RQ1, we hypothesize that achievement in each domain will positively relate to task value in that same domain. Math achievement is hypothesized to negatively relate to English task value and vice versa, as they are the most dissimilar subjects (Möller & Marsh, 2013). Science achievement (students typically took a general science course in the 9th grade that included aspects of both biology and chemistry) is hypothesized to positively relate to biology and physical science value, but no hypothesis is made regarding the relations between science domains and math and English values (Marsh et al., 2015). Regarding RQ2, we hypothesize that from 10th to 12th grade, math and English task values will negatively relate to one another, math and physical science task value will positively relate to one another, and biology and physical science will positively relate to one another. We do not have specific hypotheses of the relations between each science domain and English. In regard to RQ3, we hypothesize that math and physical science values will positively predict math intensive majors, whereas English value will negatively predict math intensive majors. We hypothesize that there will be no relation between biology value and the math intensiveness of one's college major, as biology is moderately math intensive. For RQ4, we hypothesize that males will have higher math and physical science values than females (Chow et al., 2012), and females will have higher English values than males (Archambault et al., 2010). We also hypothesize that males will select more math-intensive college majors than females, and such gender differences will be mediated through the gender differences in students' task values.

Method

Participants

The data used in this study come from the Michigan Study of Adolescent and Adult Life Transitions (MSALT). MSALT is a longitudinal study that began in 1983, when participants were in the 6th grade and included 2451 students.[1] The participants were predominantly White (91%) and middle class.[2] The data used in the present analysis includes three waves of data when participants were in 10th grade (age 16), 12th grade (age 18), and two years after high school graduation (age 20-21 in 1992-1993). This study uses a subsample of 1278 students who reported survey data in high school, even if they did not attend college. Most of the attrition from 6th grade to 10th grade was due to reducing the number of schools involved in the study during the high school years. The students from schools that did not participate in high school data collection had slightly lower math values and math achievement in 6th grade. The data used were obtained from student surveys and school records from 12 schools. Students completed surveys

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[1] Nearly every published paper using MSALT data has analyzed motivation from a single academic domain, such as how math motivational beliefs (e.g., self-concept of ability/task-value) predict math performance or math-related choices. Our paper makes use of MSALT in a novel way by investigating motivation across multiple academic domains to understand academic behavior. Due to recent developments in dimensional comparison theory research, we bridge EVT and DCT by empirically investigating motivation as a system comprised of multiple academic domains.

[2] Maternal education was measured in MSALT and has been used as a predictor of students' motivation and academic choices in numerous prior studies. In this sample of middle class families in Michigan, maternal education showed very little variability, as 73% of mothers' highest education was either a high school degree (39%) or some college classes (34%). Only 14% of mothers had college degrees (179 out of 1261 mothers). Due to the limited variability and prior knowledge that maternal education did not predict student motivation or college major, we have not included it as a predictor in this analysis.

in school classrooms in high school and surveys were mailed to the participants homes two years after high school. Grades were collected from high school record data.

Measures

Subjective task values (STV). STV was measured for the subjects of math, English, biology, and physical science in both 10th and 12th grade. Three items were used to measure each domain, including one item each related to individual interest/intrinsic value, attainment and importance value, and utility value. Each domain included the following items: (1) “How much do you like doing X? (2) For me, being good at X is ...; (3) How useful do you think high school X will be for what you want to do after you graduate and go to work? All items were measured on a Likert scale from 1 (a little/not at all important/not at all useful) to 7 (a lot/very important/very useful). All task value scales had good reliability (α = .77 to .90).

College major. Students filled in their college major in an open-ended item asking, “What is your college major?” Current college major was reported by students two years after high school. College major was coded from 1 to 4 for level of math required based on an adapted version of Goldman and Hewitt’s (1976) scale for coding STEM-related majors. The adapted scale categorizes college majors based on the level of math required from (1) little to no math, (2) some math, (3) moderate math, and (4) intensive math. The level of math required per major was based on the average number of math courses required by each major. The adapted version was used and updated by Musu-Gillette et al. (2015). For college majors not existing in the scale, two coders independently categorized majors based on similarities with other majors. The coders initially agreed on 90% of the majors, and any discrepancies were discussed until 100% agreement was reached. For example, forestry and tourism were coded as majors requiring some math (2) and drafting and aviation were coded as majors requiring moderate math (3). 131 students had declared double majors, in which case the major with the highest level of math was considered in the analysis. Categories of college majors by level of math required are shown in Table 1.

Achievement. Academic achievement was measured using the grade for each subject at the end of 9th grade as reported by the school district. Grades were scaled from 1 (F) to 16 (A+).

Attrition and Missing Data

The data from MSALT include a complex pattern of complete and missing data. From the subsample of 1278 students who participated in 10th grade, 1079 completed questionnaires two years later about college (16% attrition). The participants who did not complete the college-related questionnaire had lower achievement in high school than those who completed the questionnaire. Of the 1079 respondents, 278 reported not being in college (26%) and 791 reported being in college (73%). Respondents who were not enrolled in college had lower high school achievement than those enrolled in college. Of the 791 college students, 673 reported a college major, 78 were undecided, and 40 did not respond to the question about college major. The participants reporting a college major had higher achievement in high school than those not reporting a major. Females were more likely to have remained in the study after high school than males. In order to deal with the missing data, full-information maximum likelihood (FIML) was used, as FIML takes all information into account when estimating model parameters. Assuming the data are missing at random, FIML will produce parameter estimates that have optimal large-sample properties of consistency, asymptotic efficiency, and asymptotic normality when sample sizes are large (Allison, 2003). Data were considered missing at random if the pattern of missing data is captured in other measured variables. As the individuals with missing data varied on a number of measured variables, we felt reassured that our use of FIML was warranted.

Analysis Plan

Structural equation modeling was used to examine the relations between achievement, subjective task values, and college major. All analyses were estimated with structural equation models (SEM) in Mplus v7.4 (Muthén & Muthén, 2015). In preliminary analyses, we followed a multi-step process to develop the measurement model, including testing the factor structure and measurement invariance over time and across gender. After specifying the measurement model, we included the structural components of achievement to test RQ1, cross-lags of values over time to test RQ2, and math intensiveness of college major to test RQ3. Multi group analysis and model constraints were used to test for gender differences. The full longitudinal SEM model included eight latent variables (four at each time point) with three indicators each (see Figure 1 for a hypothesized diagram of the SEM model). Science, English, and math grades in 9th grade predicted all four task values in 10th grade. All four task values in 10th grade predicted task values in 12th grade. 12th grade values predicted college major. Residual variances for similar items between math and physical science were correlated, in addition to residual variances for similar items between biology and physical science. The variances were freely estimated for 10th and 12th grade STV. Furthermore, we added gender in our model to test RQ4. In the model, gender predicted all four task values in 10th grade and college major. To test the indirect effect of gender on college major choices, we used 95% bias-corrected bootstrapped confidence intervals based on 1,000 iterations (Preacher & Hayes, 2008).

Model fit for all models was first assessed using the chi-squared statistic (χ^2), as it is the only inferential statistic in SEM for model fit. However, as χ^2 is sensitive to large sample sizes, we used two alternative fit indices, the root mean error of approximation (RMSEA) and the comparative fit index (CFI). RMSEA values below .08 and CFI values greater than .90 indicated good fit (Acock, 2013; Little, 2013). All nested models were evaluated for model fit based on ΔCFI<.01 (Cheung & Rensvold, 2002; Little, 2013).

Results

Preliminary Analyses

Before addressing our specific research questions, there were a few descriptive findings worthy of mention. Descriptive statistics for all study variables can be found in Table 2 and Table 3. Task values for all four domains decreased between 10th and 12th grade.[3] Physical science task value was the lowest of all the domains at both time points, whereas English task value was the highest. Fifteen percent of students were enrolled in college majors categorized as requiring little to no math (e.g., humanities), 37% were in majors requiring some math (e.g., psychology), 23% were in majors requiring a moderate amount of math (e.g., biology), and 25% were in majors requiring an intensive amount of math (e.g., engineering). Females (M = 2.42, SD = .98) were enrolled in less math intensive college majors than males (M = 2.78, SD = 1.05) two years after high school ($t(671) = 4.56$, $p < .001$).

The structural equation model used to answer our research questions fit the data well (χ^2 = 1371.35(612), $p < .001$; RMSEA = .04; CFI = .94). The final model constrained the loadings over time and between genders and constrained the intercepts between genders to achieve strong

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[3] We tested mean differences in task values using both manifest and latent variables. Scalar invariance was imposed when testing for latent mean differences in task values over time. The results were consistently the same.

factorial invariance (see Table 4 for model fit for the nested models). See Table 5 for detailed results of the SEM and Figure 2 for a path diagram of significant results.

Achievement and Task Values

To answer our first research question about the associations between achievement and task value in each domain, we looked at the predictive effects of achievement in math, science, and English at the end of ninth grade on task value for math, biology, physical science, and English in grade 10. Math STV in 10th grade was predicted by math achievement at the end of ninth grade ($B = .28$, $p < .001$). Science achievement also predicted math STV in 10th grade ($B = .12$, $p = .004$). English achievement did not predict math STV. English STV was only predicted by English achievement ($B = .27$, $p < .001$). Science achievement predicted both physical science STV ($B = .28$, $p < .001$) and biology STV ($B = .28$, $p < .001$).

Relations between Task Values Over Time

To answer our second research question about the associations between task values over time in high school, we looked at the effects of all four task values in 10th grade on all four task values in 12th grade. Math STV in 12th grade was predicted by math STV in 10th grade ($B = .59$, $p < .001$) and the cross-lag of English STV in 10th grade ($B = -.09$, $p = .032$). English STV in 12th grade was predicted by English STV in 10th grade ($B = .62$, $p < .001$) and the cross-lag of math STV in 10th grade ($B = -.12$, $p = .013$). Physical science STV in 12th grade was predicted by physical science STV in 10th grade ($B = .53$, $p < .001$) and the cross-lag of math STV was nearly significant at typical alpha levels ($B = .08$, $p = .064$). Biology STV in 12th grade was only predicted by biology STV in 10th grade ($B = .53$, $p < .001$).

Task Values and College Major Selection

To answer our third research question about the associations between task values and college major choice, we looked at the effects of all four task values in 12th grade on the math-intensiveness of college major. Math STV in 12th grade was positively associated with math intensive college major ($B = .42$ $p < .001$). Inversely, English STV in 12th grade was negatively associated with math intensive college major ($B = -.27$, $p < .001$). Physical science STV was positively associated with math intensive college major ($B = .21$, $p = .001$). Biology STV was negatively associated with math intensive college major ($B = -.13$, $p = .047$). Ordered logistic regression analyses were run as a robustness check, and the results confirmed the aforementioned findings. In order to test whether gender moderated the associations between task value and college major, equal structural paths were imposed on the four STV predictors of college major and evaluated by Wald's test. The difference in coefficients between genders was not significant ($\chi^2 = 3.77(4)$, $p = .44$).

Gender Differences in Task Values and College Major Selection

We found (latent) mean differences in task values between genders. Females had higher English task value than males in 10th ($d = .94$, $z = 8.65$, $p < .001$) and 12th grade ($d = .80$, $z = 6.79$, $p < .001$). Males had higher physical science task value than females in 10th grade ($d = .35$, $z = 4.53$, $p < .001$) and 12th grade ($d = .51$, $z = 6.75$, $p < .001$). Males had higher math value only in 12th grade ($d = .26$, $z = 3.15$, $p < .001$). See Appendix for information pertaining to the latent mean models.

We added gender to the model to answer our fourth research question. The model fit the data well ($\chi^2 = 977.40(307)$, $p < .001$; RMSEA = .04; CFI = .95). See Figure 3 for the results of the model. We found no significant direct effects of gender on students' college major selection ($B = -.05$, 95% CI [-.13, .03]). However, gender (i.e., being female) predicted physical science value

($B = -.13$, $p < .001$), English value ($B = .26$, $p < .001$), and math value ($B = -.08$, $p < .05$). We found that task values mediated the effect of gender on college major choice ($B = -.10$, 95% CI [-.13, -.07]). That is, gender differences in college major selection were explained through the differences in task values between genders.

Discussion

The present study, framed by SEVT, the I/E model, and DCT, examined the relations between achievement, subjective task-values across four domains, and college major choice. We found that domain-specific achievement in ninth grade predicted subjective task values for those domains in tenth grade, in addition to a few cross-domain dimensional effects. We also found evidence of cross-domain comparisons of subjective task values from tenth to twelfth grade. Finally, subjective task values for biology, physical science, math, and English were predictive of the math intensity of selected college majors.

Cross-Domain Comparisons Between Achievement and Task Values

Pertaining to the relations between achievement and task values, our findings have some similarities and differences from I/E and DCT literature. Overall, our findings provide further evidence that task value in a particular domain is related to achievement in that domain. We also found some evidence that task value in a domain may be related to achievement in a different domain.

Math achievement was positively associated with math task value, and English achievement was positively related to English task value. However, no dimensional comparisons across these two distal domains were observed. Math achievement did not relate to English task value, nor did English achievement relate to math task value. Our findings suggest that the nature of dimensional comparisons between achievement and self-concept may differ from the nature of dimensional comparisons between achievement and task values. This discrepancy may partially be explained by expectancy-value literature that suggests the relations between achievement and task value may be mediated by self-concept of ability (Gaspard et al., 2018, Nagy et al., 2008). Thus, it may be that achievement influences self-concept of ability first, and as students feel a sense of competence in a domain, they likely attach more value to that domain. Additionally, Wigfield et al. (2020) found the strength of association from achievement in a domain to a students' valuing of that domain to be much smaller than the association between achievement and self-concept. They suggested that this finding indicates that self-concept is more closely tied to achievement and that students use other sources of information beyond achievement in determining how much they value a task.

Although math and English did not show any cross-domain comparisons between achievement and task value, we did find some evidence of cross-domain comparisons between science achievement and math task value. Science achievement positively predicted math task value, which is consistent with DCT findings (Marsh et al., 2015). This finding suggests that although the overall relations between achievement and task value are not as strong as typically found between achievement and self-concept, that self-concept may not fully mediate the relationship between achievement and cross domain values. While our findings were generally in line with findings by Gaspard and colleagues (2018), we believe that the differences may partially be explained by how task value was measured. We conceptualized task value as a latent construct comprised of interest value, utility value, and attainment value, whereas Gaspard and colleagues separated each component of value into its own latent construct. Therefore, the strength of associations differed between our studies as our inquiry pertained to the shared variance of the individual properties of task value and its relation to college major. This methodological difference raises an important question about the appropriate method for modeling the latent construct of task value. If the underlying components of task value truly form a common factor, then treating them as one latent variable may be more appropriate when modeling task value as a predictor of academic choice. Future research should investigate this matter further.

Development of Task Values Across Domains

Pertaining to the development of task values over time in high school, we found that task values exhibited a fair amount of stability in high school, as the matching domain value in 10th grade strongly predicted the same value in 12th grade. A number of cross-domain relations emerged that demonstrate how task values may affect one another over time. Prior math task value was negatively associated with future English task value and prior English task value was negatively associated with future math task value. Prior math value was also positively associated with future physical science task value. Contrary to our hypothesis and DCT findings, task value for each science domain did not relate to each other over time.

These findings are an important extension of research on dimensional comparison processes. Although dimensional comparisons often consider the relation between achievement and motivation (e.g., self-concept or subjective task value), our findings demonstrate how task values across domains relate to one another over time as a developmental process. The developmental process of a particular task value cannot be fully understood by studying it in isolation. Rather, the development of task values are best understood by looking at the system of task values that simultaneously develop within a person.

College Major Selection

We found that multiple values relate to the choice of taking a math intensive college major. While math task value most strongly predicted selecting a math intensive major, physical science task value was also a positive predictor. Inversely, English and biology task value were negatively related to selecting a math intensive major. These findings are fundamentally important to theories of motivation. Just as Eccles (1994) rejected the assumption that the decision to take advanced math courses is based on variables related to math, we find evidence that both far domains such as English and near domains such as physical science may influence math related academic choices. We believe that other task values may reinforce the road one may take, whereby interest, utility, and attainment value for a domain such as physical science may increase the likelihood of taking a math intensive major. Conversely, task value for English may detract someone from a math related major towards a field that allows one to engage in more literacy based activities, as that is what such an individual is interested in, finds useful, and identifies with. Thus, it seems in the presence of a difficult academic choice such as college major, that values are activated and used as guiding principles (Schwartz, 2013).

Gender Differences in Task Values and College Major Selection

Consistent with existing literature, we found gender differences in task values (e.g., Jansen et al., 2021) and in math-intensive college major selection (e.g., Cimpian et al., 2020). Previous research has not demonstrated that gender differences in math task value explains gender differences in math related career choices (Lauermann et al., 2017). This may be due to the focus on math task value alone. In our study, we found gender differences in task values for math, English, and physical science, which is in line with the extant literature. Furthermore, the gender difference in college major selection is explained in our model by the gender differences in task values across these domains. Cross-domain comparisons, especially between English and math values, appear to influence women away from math intensiveness majors, as they may gravitate towards majors that align with their higher value for language-oriented majors and away from majors that align with lower value for math-oriented majors. This finding is congruent with previous research that has suggested cross-domain comparisons of achievement may explain a large portion of gender differences in math-intensive fields (Breda & Napp, 2019; Wang et al., 2013). Our study adds to these findings by demonstrating the role of cross-domain comparisons of academic task values in explaining the gender gap in STEM major choices.

Practical Implications

In addition to the theoretical implications of our study, our findings have practical implications for research and practice. First, motivational interventions have realized that utility value is a lever that can be pulled to change the value a student holds for a particular domain (Flunger et al., 2021; Harackiewicz et al., 2012; Hulleman et al., 2010). While these interventions have shown some success, our study highlights that task values do not develop in isolation. Rather, they appear to be part of a dynamic system of motivational values, where tinkering with task value in one domain may positively or negatively influence task value in another domain. There is some evidence of these unintended side effects, as German students who were given a utility value intervention in math showed declined value for German, even five months after the intervention (Gaspard et al., 2016). Therefore, interventionists need to proceed cautiously when designing interventions to ensure that student autonomy is not short-circuited through manipulation of values, especially if the intervention is given during crucial stages of values and identity development. Additionally, possible side effects may need to be disclosed to parents, teachers, and students. On the flip side, interventions that are ethically designed can also use our findings to consider alternative angles to boost value by using near domains that support the targeted domain. For example, if the intervention is aimed at getting more students to consider math intensive careers such as engineering, interventions may consider targeting a near domain such as physical science.

Conclusion & Limitations

The present study shed light on cross-domain comparisons of math, English, biology, and physical science task value and their role in college major choice. We have contributed to the literature on values and motivated academic behavior by considering how internal cross-domain comparisons of academic domains occur and develop in adolescence and influence college major choice. Our findings have many theoretical implications for I/E, DCT, and SEVT research. Furthermore, our findings have practical implications for intervention research. Understanding how task values develop and relate to academic choices has been the subject of motivational research for decades. Although most task value research has relied on single-domain analyses, our study demonstrates the utility of considering multiple academic domains that students study and develop values for as part of a dynamic motivational system.

Our findings shed light on the importance of considering multiple subjective task values on both the development of subsequent task values and on academic choices. However, there are a few limitations that must be considered when interpreting the results. The study relied on correlational data, thus making strong causal claims less tenable. The sample was predominantly White and middle/working class, which may limit generalizability to other populations. College major data were collected approximately two years after high school graduation, and we are not aware if and when students changed majors. Future studies should investigate college majors intended and realized, in order to understand the intention-behavior gap in college achievement. Finally, the data utilized in this study were collected a few decades ago, and whether or not our findings would replicate today is an empirical question. However, gender differences in college major selection are still evident today, and we do not have any reason to suspect that the underlying mechanisms and psychological processes have changed in the past few decades. Nonetheless, we suggest future studies consider diverse populations and utilize more recent data to test whether the associations have changed in any way. Furthermore, being able to determine if there have been any historical changes depends on having solid findings from multiple time points. Our findings contribute to the knowledge of gendered processes from those who were making careered related educational choices in the past few decades.

Future research should also consider directly assessing dimensional comparisons. Within expectancy-value research, self-concept surveys include items about self-concept in a domain relative to other domains. Similarly, subjective task-value surveys should also include items about task value for one domain compared to others. This may help us measure task value more accurately and enhance prediction of motivated behavior. Finally, we believe more person-centered approaches should be utilized to study the cooccurrence of subjective task values, including methods such as cluster analysis and latent profile analysis. These methods may better explain heterogeneity in the profiles of subjective task values and whether various motivational profiles explain academic behavior (Fong et al., 2021; Umarji et al., 2021). In a complex motivational system, such as subjective task values, each value does not function independently of other values, which is a limitation of using variable-centered approaches. Thus, person-centered methods may help strengthen and refine our understanding of task-values and motivated academic behavior.

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Table 1

College majors classified based on the level of math intensiveness

Little to no math (1)	Some math (2)	Moderate math (3)	Intensive math (4)
Humanities	Psychology	Biology	Math
English/Literature	Sociology	Pharmacy	Engineering
Philosophy	Political Science	Economics	Computer Science
International Studies	Social Work	Science (other)	Chemistry
History	Nursing	Architecture	Physics
Music/Theater/Film	Health	Physiology	Finance
Foreign Languages	Anthropology	Astronomy	Accounting
Art	Counseling	Geology	Electronics

Table 2

Means, standard deviations, and scale alphas of observed variables

	N	Mean	*SD*	Min	Max	Scale α
Math STV 10th	1278	4.74	1.47	1	7	0.77
English STV 10th	1274	4.75	1.51	1	7	0.81
Biology STV 10th	1246	4.17	1.65	1	7	0.86
Physical Sci STV 10th	1205	4	1.57	1	7	0.83
Math STV 12th	1231	4.49	1.52	1	7	0.8
English STV 12th	859	4.58	1.59	1	7	0.84
Biology STV 12th	861	3.65	1.78	1	7	0.9
Physical Sci STV 12th	1230	3.76	1.67	1	7	0.85
Math Ach Grade 9th	1117	9.79	3.01	1	16	-
English Ach Grade 9th	1175	10.27	2.99	1.5	16	-
Science Ach Grade 9th	1147	10.56	2.88	2	16	-
Gender (Female)	1278	-	-	-	-	-
Math intensive major	673	2.58	1.02	1	4	-

Table 3

Correlations of observed and scaled variables

	1	2	3	4	5	6	7	8	9	10	11	12
1. MSTV10	1											
2. ESTV10	0.15***	1										
3. BSTV10	0.28***	0.19***	1									
4. PSSTV10	0.34***	0.15***	0.64***	1								
5. MSTV12	0.51***	-0.06	0.12***	0.22***	1							
6. ESTV12	-0.10*	0.52***	0.11**	0.00	-0.10**	1						
7. BSTV12	0.17***	0.01	0.56***	0.42***	0.22***	0.11***	1					
8. PSSTV12	0.24***	0.04	0.42***	0.57***	0.36***	-0.02	0.64***	1				
9. Math 9	0.27***	0.06*	0.09**	0.13***	0.25***	0.03	0.12***	0.13***	1			
10. English 9	0.14***	0.21***	0.15***	0.11***	0.09**	0.20***	0.19***	0.12***	0.55***	1		
11. Science 9	0.19***	0.08**	0.22***	0.23***	0.13***	0.11**	0.23***	0.20***	0.55***	0.67***	1	
12. Female	-0.07**	0.29***	0.03	-0.11***	-0.11***	0.27***	-0.02	-0.15***	0.08***	0.17***	0.07**	1
13. Major	0.32***	-0.22***	0.10*	0.21***	0.47***	-0.31***	0.11*	0.33***	0.19***	0.07	0.17***	-0.17***

Note. Subjective task value (STV) variables are scaled values for each subject. Math 9, Eng 9, and Sci 9 are all end of 2nd semester grades in 9th grade. MSTV = math STV; ESTV = English STV; BSTV= Biology STV; PSSTV= Physical science STV.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 4

Comparison of nested longitudinal models

Form	χ2(df)	RMSEA	CFI	$\Delta\chi^2$	Δdf	p_Δχ²	ΔCFI
1 Configural (unconstrained)	1217.8(564)***	0.04	0.95	-	-	-	-
2 Equal loadings over time	1240.8(580)***	0.041	0.95	23	16	0.113	0.001
3 Equal loadings over time & gender	1258.9(588)***	0.041	0.949	18.1	8	0.02	0.001
4 Equal loadings over time & gender & equal intercepts between genders	1371.3(612)***	0.043	0.943	112.4	14	0.00	0.006

Note: Each nested model was tested with the previous model to assess model fit. Model 2 was compared to model 1, model 3 to model 2, and model 4 to model 3. p_Δχ² refers to the p value of the χ^2 difference tests.
All nested models were evaluated based on ΔCFI < .01.

Table 5

Cross-domain comparisons of subjective task values and college major choice

	B	SE	*p*-value
Achievement and STV			
Math Grade 9 → Math STV 10	0.276	0.037	0.000
English Grade 9 → Math STV 10	-0.040	0.043	0.348
Science Grade 9 → Math STV 10	0.123	0.043	0.004
Math Grade 9 → English STV 10	-0.020	0.037	0.600
English Grade 9 → English STV 10	0.274	0.041	0.000
Science Grade 9 → English STV 10	-0.025	0.042	0.559
Math Grade 9 → Physical Sci STV 10	0.016	0.037	0.678
English Grade 9 → Physical Sci STV 10	-0.054	0.042	0.202
Science Grade 9 → Physical Sci STV 10	0.282	0.041	0.000
Math Grade 9 → Biology STV 10	-0.042	0.036	0.247
English Grade 9 → Biology STV 10	0.004	0.041	0.925
Science Grade 9 → Biology STV 10	0.281	0.040	0.000
Lagged STV Paths			
Math STV 10 → Math STV 12	0.590	0.038	0.000
English STV 10 → Math STV 12	-0.085	0.040	0.032
Biology STV 10 → Math STV 12	-0.001	0.055	0.983
Physical Sci STV10 → Math STV 12	0.045	0.057	0.435
Math STV 10 → English STV 12	-0.123	0.050	0.013
English STV 10 → English STV 12	0.623	0.039	0.000
Biology STV 10 → English STV 12	0.072	0.059	0.225
Physical Sci STV10 → English STV 12	-0.030	0.063	0.633
Math STV 10 → Biology STV 12	0.050	0.047	0.286
English STV 10 → Biology STV 12	-0.052	0.044	0.237
Biology STV 10 → Biology STV 12	0.532	0.055	0.000
Physical Sci STV10 → Biology STV 12	0.052	0.062	0.402
Math STV 10 → Physical Sci STV 12	0.075	0.041	0.064
English STV 10 → Physical Sci STV 12	-0.052	0.037	0.163

Biology STV 10 → Physical Sci STV 12	0.078	0.052	0.134
Physical Sci STV10 → Physical Sci STV 12	0.534	0.053	0.000
STV 12 & College Major			
Math STV 12 → College Major	0.415	0.046	0.000
English STV 12 → College Major	-0.268	0.047	0.000
Biology STV 12 → College Major	-0.130	0.065	0.047
Physical Sci STV 12 → College Major	0.208	0.065	0.001

Note. All results are standardized.

Figure 1

SEM of Achievement, Task Values and College Major

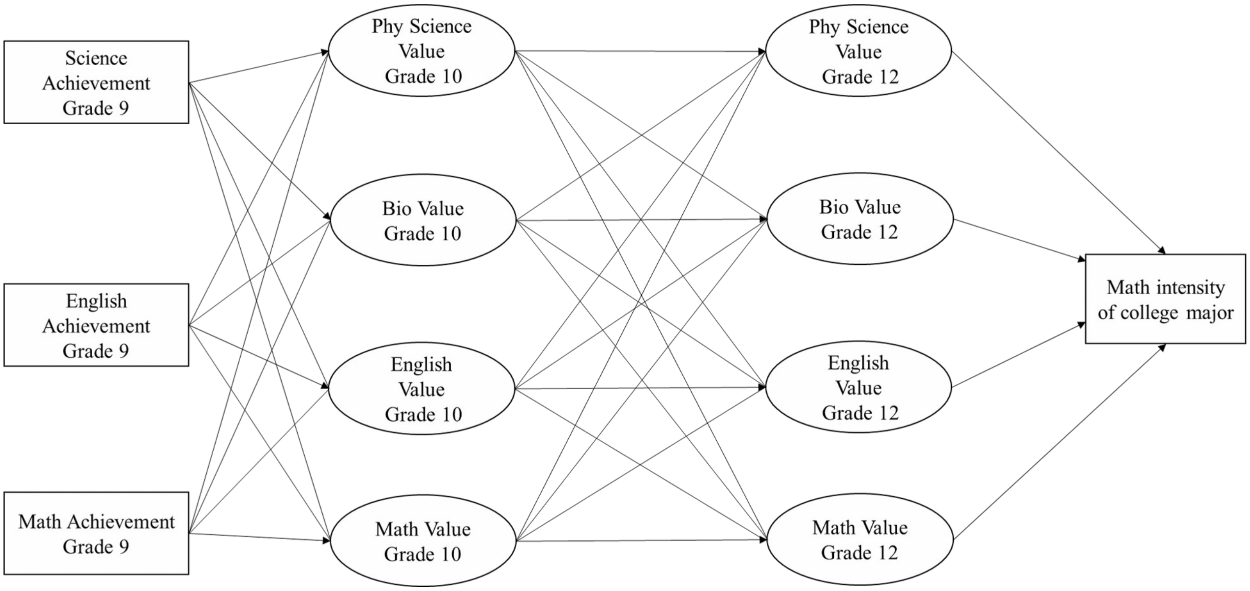
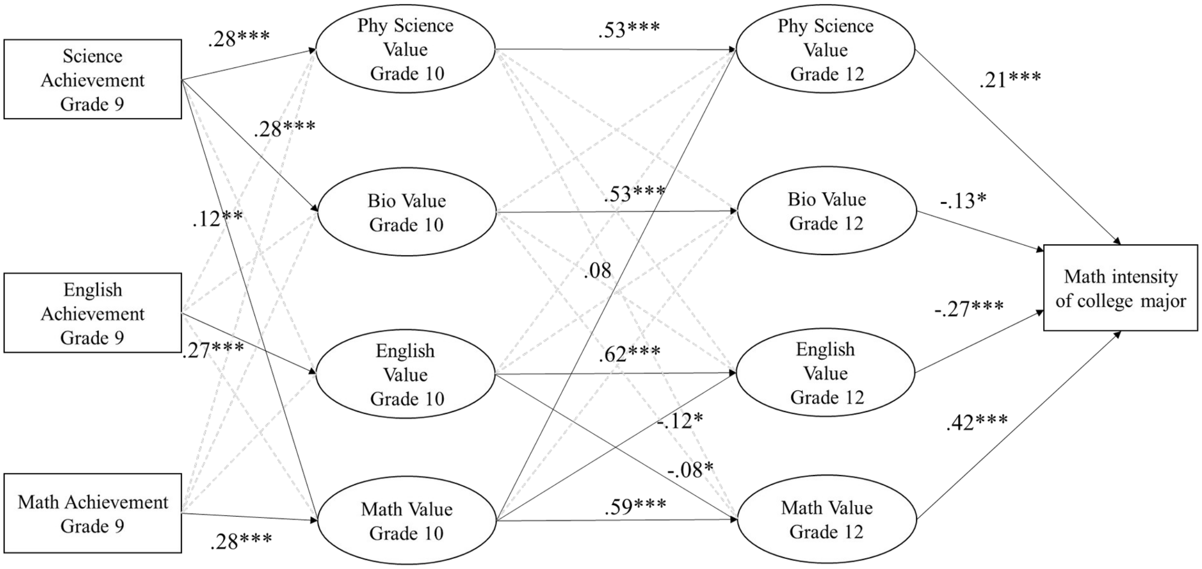


Figure 2

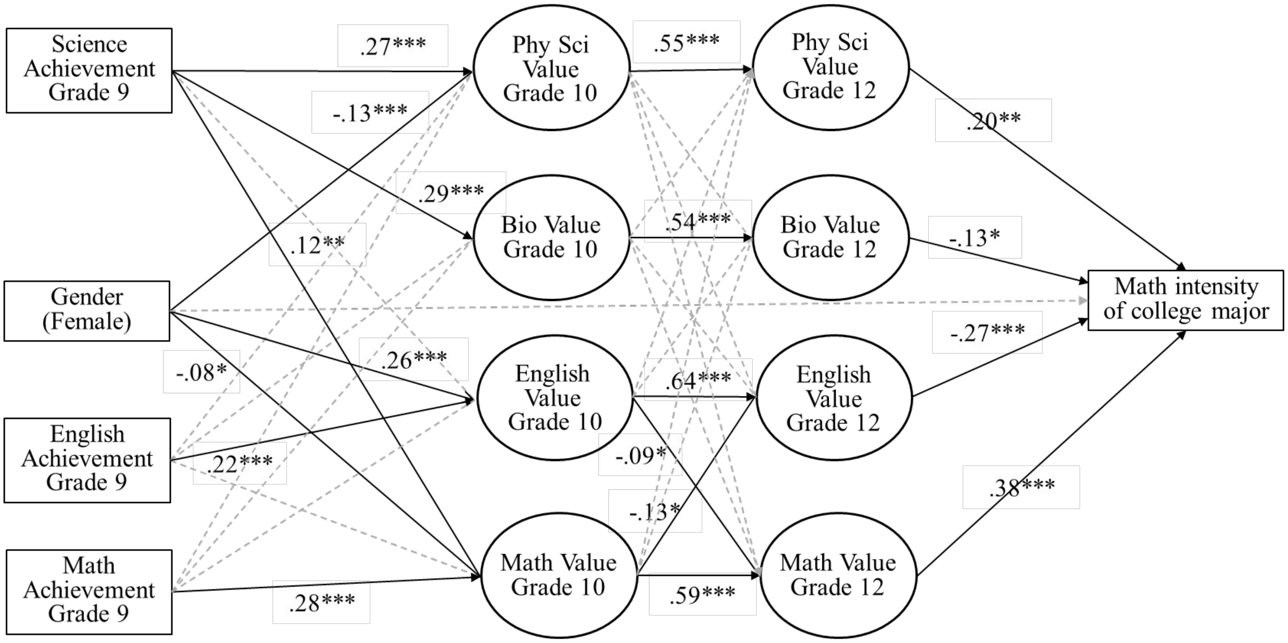
Final Structural Equation Model



Note. All coefficients are standardized. Solid lines represent significant paths ($p < .05$). Dashed lines represent paths that were not significant ($p > .05$). Correlated residual variances are not shown in the figure.

Figure 3

Structural Equation Model with Gender Included



Note. All coefficients are standardized. Solid lines represent significant paths ($p < .05$). Dashed lines represent path that were not significant ($p > .05$). Correlated residual variances are not shown in the figure.

Appendix

Multi-group analyses were used to generate latent means for all subjective task values in 10th grade and 12th grades for males and females. The means for all latent variables for males were fixed at zero, and the corresponding females means were interpreted as differences in means. Corresponding p-values were used to determine whether mean differences were significant or not.

The model fit was acceptable for the two models for grades 10 and 12 (χ2= 397.153/358.404, p<.001, RMSEA=.069/.065, CFI=.959/.961). Females had significant (p<.001) latent mean differences in English and physical science STV compared to males in 10th grade. For English, females had a mean English STV that was .94 greater than that of males. Conversely, females had a mean physical science STV that was .35 less than that of males. In 12th grade females had a latent math STV mean that was .35 less than males (p=.001), English STV mean was .92 greater than males (p<.001), and physical science STV that was .72 less than males (p<.001). There were no significant differences in biology STV at either grade (p=.823/.145).