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Leaks in the Pipeline to Math, Science, and Technology Careers

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This chapter addresses how critical choices in the math and science pipeline can be traced back to adolescents' self-concepts of abilities and values at the beginning of high school.

The Intersection Between Self-Concepts and Values: Links Between Beliefs and Choices in High School

Sandra D. Simpkins, Pamela E. Davis-Kean

The occupational landscape in the United States has experienced major shifts in the past several decades. Manual labor is often outsourced to other countries due to the differential labor expenses. New jobs have emerged due to advances in technology, and other jobs have evolved to incorporate math, science, and technology. Math and science skills are necessary not just to succeed as an engineer or chemist, but are now essential for obtaining many jobs in the United States. Yet parallel changes are not evident in the number of young adults who obtain degrees common in these occupations (such as engineering, chemistry, and the social sciences). Female representation in these fields is particularly low (National Science Foundation, 2004). For example, in 2001, only 2 percent of females who obtained a bachelor's degree earned their degree in engineering (compared to 9 percent of males;

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National Science Foundation, 2004). Why are so few students, particularly female students, opting or dropping out of the math and science pipeline?

Previous research suggests that gender differences in math and science are evident in adolescents' high school choices (Eccles (Parsons), Adler, and Meece, 1984; Farmer, Wardrop, and Rotella, 1999; Updegraff, Eccles, Barber, and O'Brien, 1996). Thus, in order to understand and potentially change the success rate of adolescents' pursuit of math and science, it is important to pinpoint the origins of differences in course choices. In this chapter, we examine what motivates adolescents to choose high school courses and career goals by trying to untangle the complicated interplay between their self-concept of ability in math and science and their value of these domains. We also examine how these beliefs and values may interact with gender, which may potentially give us insight into why more women are not going into careers in math, science, and technology.

What We Know About the Links Between Adolescents' Choices and Beliefs

Theories of motivation, such as the Eccles et al. Expectancy Value Model, suggest that people's choices (for example, course selection, college major) are strongly determined by their beliefs—namely, their values (that is, feelings of importance and interest) and self-concepts (that is, beliefs about how skilled one is; Eccles, 1994). Adolescents who value math or science report higher intentions to take more elective courses in those subjects in the future (Eccles (Parsons) and others, 1985; Eccles (Parsons), Adler, and Meece, 1984; Meece, Wigfield, and Eccles, 1990; Updegraff, Eccles, Barber, and O'Brien, 1996). Similarly, when predicting actual course selection, researchers find that math values predict the number of high school math courses taken throughout high school (Eccles (Parsons), Adler, and Meece, 1984; Updegraff, Eccles, Barber, and O'Brien, 1996). More recent work points to the importance of self-concepts in predicting high school course selection (Simpkins, Davis-Kean, and Eccles, forthcoming).

Much of this work, however, is based on analyses examining values and self-concepts separately. In reality, it is likely that adolescents make choices based on their self-concepts and values. Eccles (1994) and Harter (1986, 1993) theorized that self-concepts of abilities influenced youths' values. Harter found that the congruence or dissimilarity between values and self-concepts had implications for global self-esteem. Children who are not skilled in an area are likely to place little value on it to preserve their self-esteem. As a result, values and self-concepts often match, such that children who believe they are skilled in an area are likely to value that area. Although research shows that youths' math self-concepts predicted their math values across time (Jacobs and others, 2002), it is still unclear if there are multiple unique patterns of self-concepts and values and how those differential patterns predict choices.

According to the Eccles et al. Expectancy Value Model, relations between beliefs and behaviors are shaped by broader influences, such as gender. The model suggests that gender influences beliefs and choices through gender norms and roles of particular cultures. This is evident in the divergence between children's actual performance and beliefs about their abilities. Although males' performance in math and science is similar to or lower than females' performance, males have higher self-concepts in math and science (Andre, Whigham, Hendrickson, and Chambers, 1999; Eccles and Harold, 1991; Jacobs and Eccles, 1992; Jacobs and others, 2002; Meece, Wigfield, and Eccles, 1990). Gender differences on values are somewhat mixed. The research suggests that gender is not a factor in how much math and science course work is valued (Eccles (Parsons) and others, 1985; Jacobs and others, 2002; Wigfield and others, 1991). Watt (2004), however, found gender differences when examining various components of math value. Specifically, she found that males had higher math interest than females, but they did not differ in terms of math importance. Gender has an influence on children's self-concepts, not on performance and values (with the exception of math interest). Clearly, gender appears to be an important influence on beliefs in math and science and will be a critical factor to consider in this research.

Remaining Issues

The associations between beliefs and choices need to be examined in math and science. Much of the previous research has concentrated on math. Little work addresses whether adolescents' beliefs predict the number of high school science courses, particularly enrollments in physical science versus life science courses. Given that many science and engineering degrees have math and science course prerequisites, our examination of math and science is critical.

Only a few researchers have simultaneously used self-concepts and values to predict adolescents' choices even though adolescents make choices based on their self-concepts and values. We address this divergence between theory and statistical findings by using person-centered approaches. We use cluster analysis to identify groups of adolescents who have unique patterns of self-concepts and values. By using these clusters to predict choices, we can test whether adolescents' choices hinge on having a high self-concept, high value, or high self-concept and value.

Another important issue left unresolved by previous research is the impact of adolescents' performance on the relation between their beliefs and choices. Adolescents' performance or achievement in math and science is associated with both their beliefs and choices (Eccles (Parsons) and others, 1985; Farmer, Wardrop, and Rotella, 1999; Frome and Eccles, 1998; Jacobs, 1991; Jacobs, Finken, Griffin, and Wright, 1998; Updegraff, Eccles, Barber, and O'Brien, 1996). Yet indicators of adolescents' performance are often not included when examining associations between beliefs and choices. The unique power of self-concept and value in predicting choices, beyond their very high association with performance, is often not clear. We include indicators of performance to rule out the possibility that performance is the reason that adolescents' beliefs predict their choices.

Few researchers have systematically examined if the relations between beliefs and choices vary for males and females. Researchers have largely focused the differences between genders in terms of the mean number of courses or the mean level of beliefs. Preliminary evidence suggests that although males had significantly higher math and science beliefs than females did, there were no differences in relations between beliefs and high school course enrollments (Simpkins, Davis-Kean, and Eccles, forthcoming). Mapping gender differences at mean levels and the relations between indicators is necessary to fully understand the phenomenon.

We examine four questions in this chapter to address these gaps in the literature:

1. Are there meaningful groups of adolescents who differ based on their pattern of ninth-grade values and self-concepts in math and in science?
2. Do these groups differ in terms of the number of males and females? For example, are there a higher number of males than females in groups marked by high self-concepts?
3. How do these groups vary according to their selection of high school math and science courses and intentions to pursue a science- or health-related career?
4. Do these relations discussed under question 3 differ by gender?

Method

Data from 180 children (54 percent female) who participated in the Michigan Childhood and Beyond Study (CAB; see Jacobs and others, 2002, for a full description) were used in this investigation. The sample is largely white, middle-class families; for example, 93 percent of children were European American and spoke English, and families' 1989 median annual household income was between $40,000 and $49,999. Forty-two percent of mothers and 44 percent of fathers had earned a degree from a four-year college. This study began in 1987 with three cohorts of children in kindergarten, first, and third grades and followed adolescents at least through high school. Due to the data collection design, adolescents who had information collected in ninth and twelfth grade were included in the study (that is, adolescents who were in kindergarten and first grade in 1987). Adolescents' data used in this report were collected at school during the spring of each year, using questionnaires administered in their classroom under the supervision of several staff members.

Self-Concepts and Values. In ninth grade, adolescents described their beliefs regarding their self-concept (math: five-item scale, alpha = .92, science: three-item scale, alpha = .91) and value of math and of science (math: seven-item scale, alpha = .89, science: four-item scale, alpha = .88). Adolescents' self-concept describes how good they think they are at math or at science—for example, "How good at math are you?" (range: from 1 = Not at All Good to 7 = Very Good) and "How well do you expect to do in science this year?" (range: 1 = Not at All Well to 7 = Very Well). A high score on the value subscale means that adolescents had an interest in the area and thought it was important—for example, "In general, how useful is what you learn in science?" (range: 1 = Not at All Useful to 7 = Very Useful) and "How much do you like doing math?" (range: 1 = A Little to 7 = A Lot). These scales have excellent validity and strong psychometric properties (Anderman et al., 2001; Jacobs and others, 2002). Each scale was calculated by taking the average of the items.

Number of High School Courses. In twelfth grade, participants described which math and science courses they had taken throughout high school. There were seven math courses (algebra, algebra II, geometry, pre-calculus, trigonometry, calculus, and AP calculus/AP analysis), two life science courses (biology and advance biology/AP biology), and four physical science courses (chemistry, advanced chemistry/AP chemistry, physics, and advanced physics/AP physics).

Six scales were created to examine the total number of courses and the number of advanced courses adolescents took in each of the three areas. To compute the total number of courses in each area, we counted the number of courses they took throughout high school in each area. For example, the total math courses (labeled Total Math) was calculated by counting the number of math courses adolescents took throughout high school. Scores on this scale ranged between 0 and 7. Total life science courses (labeled Total Life Science) ranged between 0 and 2, and total physical science courses (labeled Total Physical Science) ranged between 0 and 4.

A second variable was created in each area to assess the number of advanced courses adolescents took throughout high school. The number of advanced math courses was computed by summing how many calculus courses (precalculus, calculus, and AP calculus/AP analysis) adolescents took in high school. This scale, labeled Advanced Math, ranged from 0 to 3 because there were three calculus courses on the list. Very few adolescents, however, took all three courses ($n = 6$). As a result, we combined adolescents who took either two or three calculus courses. The resulting scale ranged between 0 and 2. Advanced Life Science was dichotomous (coded 0 or 1) as only one advanced course was listed for this area: advanced biology/AP biology. Two advanced physical science courses were listed: advanced chemistry/AP chemistry and advanced physics/AP physics. The two courses were counted to create the scale Advanced Physical Science (the scale range was 0 to 2). Because so few adolescents took both advanced courses (only twelve adolescents took both), we recoded the variable to indicate whether an adolescent did not take either advanced physical science course (that is, score of 0) or an adolescent took at least one advanced physical science course (that is, score of 1).

Career Plans. Adolescents described the likelihood of pursuing four types of math- or science-related professions that would require a college degree (range: 1 = Very Unlikely to 7 = Highly Likely). Two groups were created: (1) health-related careers and (2) math/science-related careers (Jacobs, Finken, Griffin, and Wright, 1998). Health-related career was represented by adolescents' ratings of pursuing a health professional career with a bachelor's or master's degree (for example, nurse, pharmacist) or advanced degree (for example, physician, veterinarian, dentist). Adolescents' career plans for a math/science career were represented by the likelihood that they would be a science or math-related professional with a bachelor's or master's degree (for example, engineer, architect) or with an advanced degree (for example, a scientist with a doctorate).

Aptitude. Children's math aptitude was measured with teachers' reports of children's ability and talent in mathematics at third grade (range: 1 = Very Little to 7 = A Lot).

Results

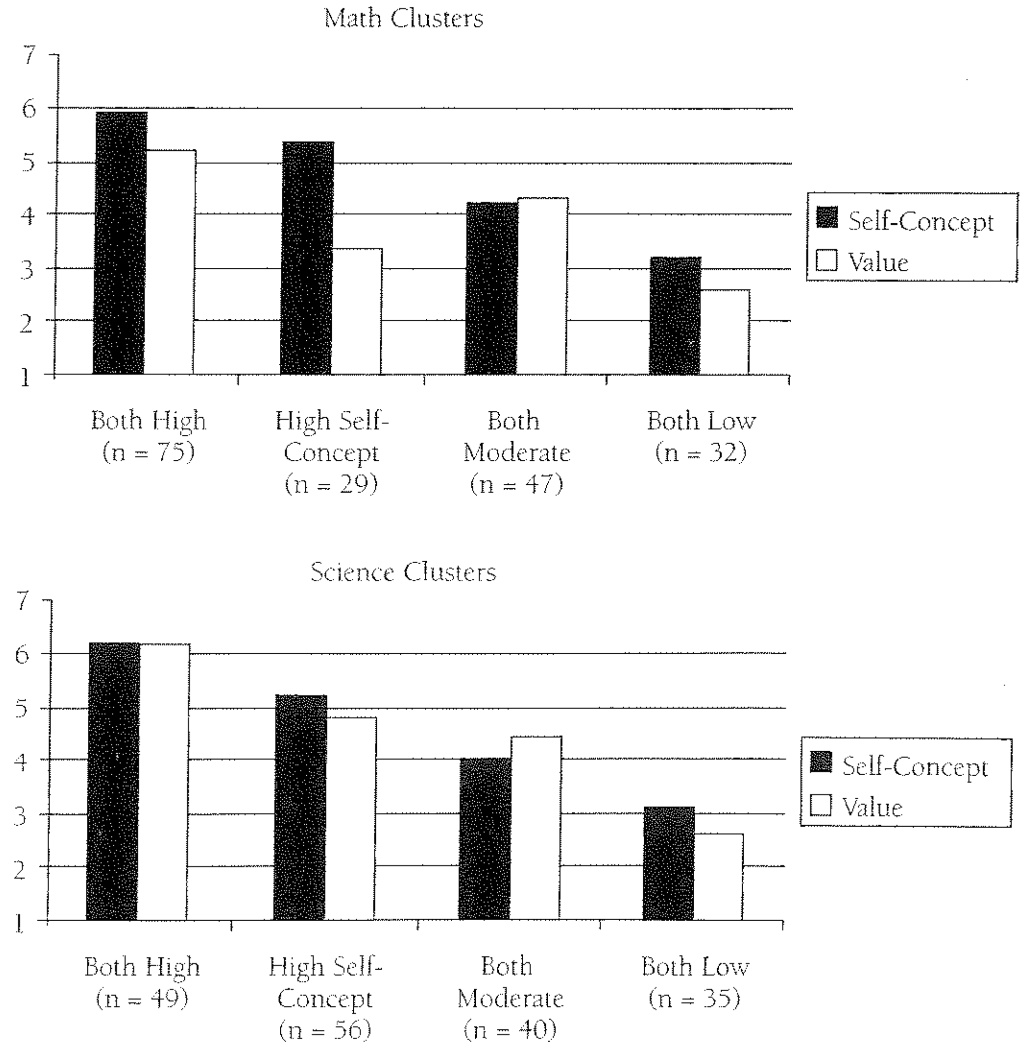
The results are organized into four sections. First, we examine whether we could identify clusters or groups of adolescents that differ in terms of values and self-concepts. Second, we test whether these clusters varied in terms of male and female representation. Third, we examine if adolescents' course selection differed by gender and cluster membership. In the final set of analyses, we complete a parallel set of analyses for adolescents' career goals.

Are There Meaningful Groups of Adolescents That Differ Based on Their Ninth-Grade Values and Self-Concepts in Math and in Science? The pipeline toward math and science careers has been described as a sequence of decisions youth need to make. Self-concepts and values have been shown to predict these various decisions. Although youth use self-concepts and values to make these decisions, researchers often examine these two beliefs separately. Before we test how self-concepts and values predict choices, we need to test if there are groups of adolescents who differ in terms of their values and self-concepts in math and in science.

Using cluster analysis, we were able to see if adolescents had different patterns of values and self-concepts (for example, high values and self-concepts versus high values and low self-concepts). Clusters (using the Ward method) were computed for math and science separately due to the high correlations between adolescents' self-concept and value within each domain. Ninth-grade math self-concept and values were entered into the analysis for the math clusters. Ninth-grade science self-concept and values were used to create the science clusters. In deciding on the number of clusters, we examined a variety of solutions, such as a one-cluster solution and a two-cluster solution. We decided to keep the solution with four clusters in each area. The four clusters in each area significantly differed from each other in terms of adolescents' values and self-concepts. Solutions that divided adolescents into a higher number of clusters (for example, five or six clusters) did not define groups that were theoretically or empirically unique from the first four clusters.

These clusters suggest that there are multiple unique patterns of values and self-concepts in math and in science as noted in Figure 4.1. The clusters mostly differentiated between youths who had high, moderate, or low self-concepts and values. There was only one cluster for math and one for science in which one belief was high and the other was low. The similarities in the math and science clusters were notable, which is evident when we examine them in further detail.

Figure 4.1. Clusters in Math and in Science Based on Ninth-Grade Self-Concepts and Values



Note: The number of adolescents in each cluster is noted in parentheses.

The cluster labeled Both High includes adolescents who had high math and science self-concepts and values. In math and science, adolescents in these clusters on average reported scores near the top of the response scales. The high ratings of value suggest that adolescents in these clusters felt math and science were very useful, important, and more useful than other activities. These adolescents also thought they were very good in the subject and perhaps one of the best students in his or her math or science class.

The second cluster, labeled High Self-Concept, also included adolescents with relatively high self-concepts, but they had lower values than the Both High cluster. This cluster differed slightly between math and science. In math, there is a notable difference between adolescents' high math self-concept and low value. In contrast, the difference between science self-concept and value was not as strong. In both cases, adolescents felt they had strong abilities in math or science. Adolescents in the math cluster felt they had relatively high math abilities but did not have a high interest in or view math as highly important. Adolescents in the science High Self-Concept cluster believed they had high science abilities and placed slightly higher-than-average importance on science and had higher-than-average interest in science.

The Both Moderate cluster includes adolescents with self-concepts and values that hovered around the midpoint of the response scale. Adolescents in these clusters on average believed they were okay at math and science and felt that these subjects were moderately useful, important, and interesting. These clusters were also unique in that it was the only cluster out of the four in which adolescents' self-concept was not higher than their value of math or science.

The final cluster, labeled Both Low, encompassed adolescents who had relatively low self-concepts and values. Although adolescents in these clusters did not report that they were very bad at math or science, they believed their skills were less than okay on average. Youths' values of math and science were relatively low too. On average, these adolescents placed little important on these domains or were likely to see these subjects as slightly boring, or both. Thus, adolescents in this group believed they have low abilities, low interest, and low importance in these domains.

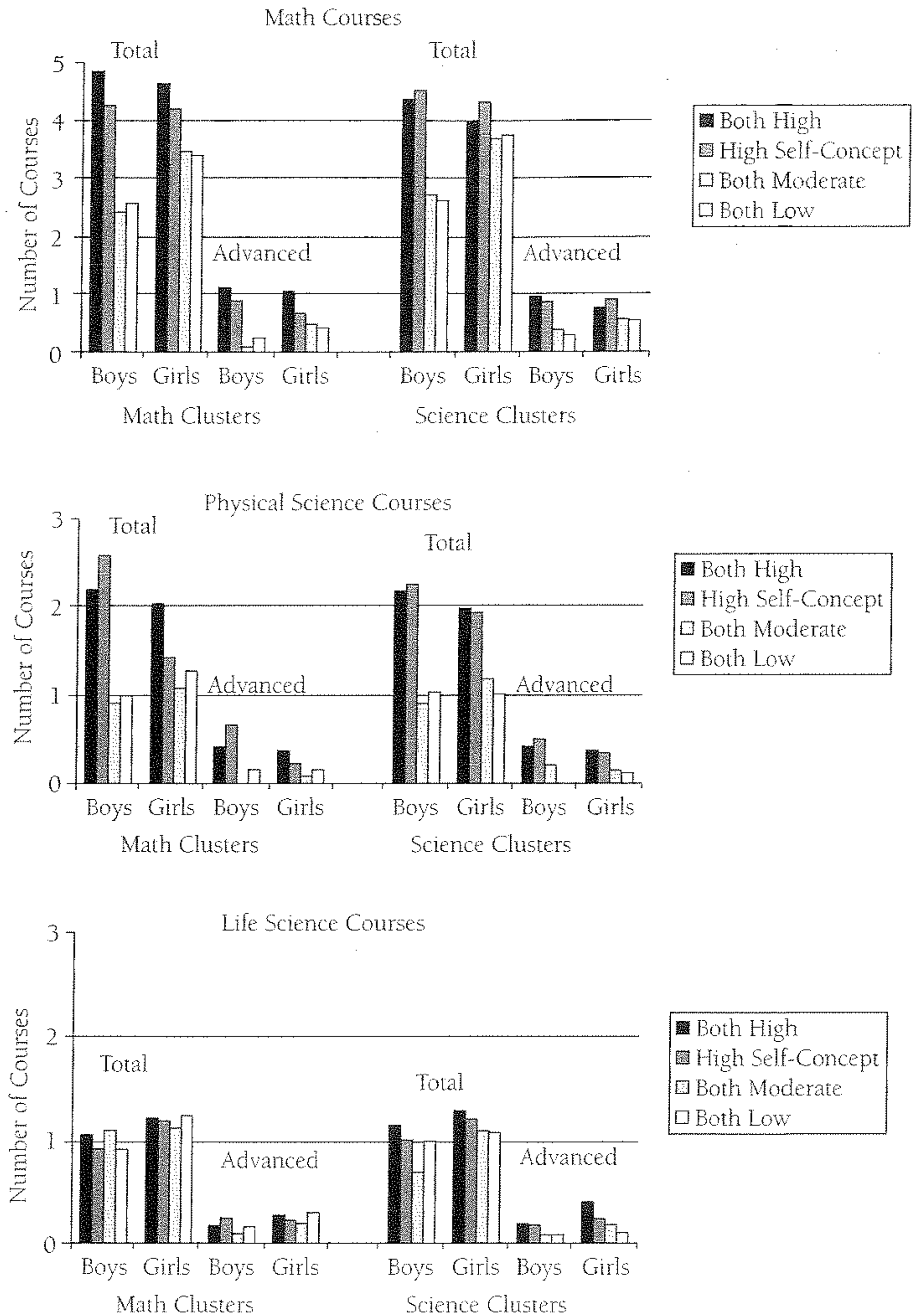
Do These Groups Differ in Terms of the Number of Males and Females? Gender differences are pervasive in the literature in math and science. One way these differences could emerge is if the pattern of adolescents' values and self-concepts differed by gender. Although research suggests that males generally have higher self-concepts in math and science than females do, we wanted to test whether there were gender differences in the patterns of values and self-concepts characterized by the clusters discussed in the previous section. We examined how males and females were distributed across these different clusters with the chi square test. The math clusters or groups did not significantly differ in terms of the number of males and females, χ^2 (3, N = 180) = 5.54, n.s. The number of males and females in the science clusters, however, did significantly differ by gender, χ^2 (3, N = 180) = 9.12, $p < .05$. Males had higher representation in the groups in which adolescents had higher-than-average science self-concepts (that is, Both High and High Self-Concept clusters). Females had higher representation in the Both Low and the Both Moderate clusters.

Do Adolescents' Course Selections Differ by Cluster and Gender? One of the main goals of this investigation was to understand the links between adolescents' beliefs and gender in predicting their course choices. The next set of analyses provide information on (1) what pattern of beliefs (or what clusters) predicts the courses adolescents take in high school, (2) if males and females differ in the courses they take, and (3) if the relations between the pattern of beliefs and high school courses are different for males and females. Analysis of covariance (ANCOVA) was used to examine the differences in the number of courses. Cluster membership, gender, and the interaction between cluster membership and gender were used to predict children's outcomes. The interaction will tell us if relations between cluster membership (or the pattern of beliefs) and course selection are different between males and females. The control variables in each analysis were cohort, parent education level, family income, and teacher ratings of math ability. The means of the number of courses are displayed in Figure 4.2 by cluster and gender. Because this chapter focuses on the impact of gender and the clusters, which are based on adolescents' values and self-concepts, we will focus on those findings. Although separate analyses were computed for the math and science clusters, we have organized the findings in terms of outcomes and discuss them together.

Total Math Courses. The number of math courses adolescents took during high school differed depending on adolescents' math cluster membership, science cluster membership, and gender (Figure 4.2). Adolescents from the two clusters notable for high math and science self-concepts (the Both High and High Self-Concept clusters) took a higher number of total high school math courses than adolescents with low to moderate self-concepts and values (all comparisons significant at least at $p < .05$). In addition, females enrolled in a higher number of total math courses than males did ($p < .05$). There was, however, a significant interaction between gender and science cluster membership. This interaction suggests that the differences between males and females are strongest for the two science clusters with low to moderate self-concepts and values: Both Low and Both Moderate. Females in the Both Low and Both Moderate clusters enrolled in a higher total number of math courses than did males in the corresponding clusters ($p < .05$). In sum, adolescents with higher-than-average math or science self-concepts, regardless of values, and females were more likely to enroll in math courses than those with moderate or low self-concepts and values and males (respectively).

Advanced Math Courses. A similar pattern emerged concerning the number of advanced math courses, without the gender differences. Adolescents

Figure 4.2. Mean Number of Science and Math Courses Taken Throughout High School, by Ninth-Grade Clusters and Gender



in the clusters with high math or science self-concepts (Both High and High Self-Concept clusters) enrolled in a higher number of advanced math courses than did adolescents with moderate or low self-concepts (the Both Moderate and Both Low clusters; all comparisons significant at least at $p < .05$ except the comparison between math Both High and math Both Low was not significant). One notable difference between the number of advanced versus total math courses was that males and females did not take a significantly different number of advanced math courses.

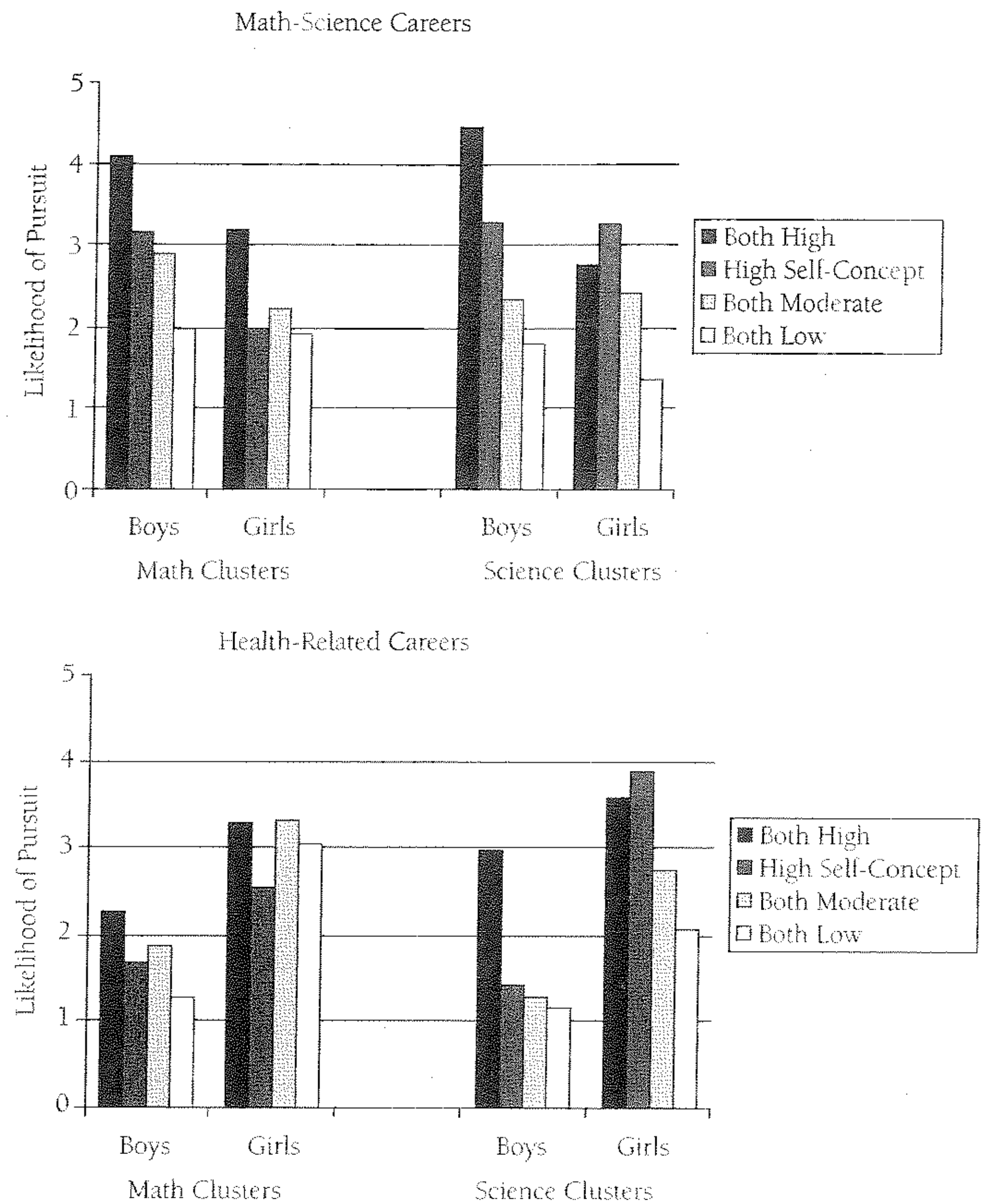
Total Physical Science Courses. We also used gender, math cluster membership, and science cluster membership to predict the number of physical science courses (Figure 4.2). Adolescents who had higher-than-average math or science self-concepts (those in the Both High and High Self-Concepts clusters) took a higher number of total physical science courses than did adolescents who had moderate or low self-concepts and values (all comparisons significant at least at $p < .01$). There was also a significant interaction between gender and math cluster membership revealing that males in the math High Self-Concept group took more physical science courses than females in the math High Self-Concept group ($p < .01$).

Advanced Physical Science Courses. We found significant differences in the number of advanced physical science courses youth took. The number of these courses taken during high school differed by cluster membership ($p < .01$) but not by gender or the interaction between gender and cluster membership. For both math and science clusters, adolescents in the two clusters with high math or science self-concepts (that is, Both High and High Self-Concept) enrolled in a higher number of advanced physical science courses than did adolescents in the two clusters with moderate or low self-concepts and values (all comparisons significant at least at $p < .05$). Two additional comparisons were significant for the math clusters. Adolescents with high self-concepts and values took more advanced physical science courses than did adolescents in the High Self-Concept cluster ($p < .05$), who in turn took more advanced courses than did adolescents with moderate math self-concepts and values ($p < .05$). As evident with the other types of courses, adolescents with relatively high math or science self-concepts were more likely to take advanced physical science courses than were adolescents with moderate or low self-concepts.

Life Science Courses. The number of overall or advanced life science courses did not significantly differ by cluster membership or gender (Figure 4.2). In other words, knowing adolescents' math or science cluster membership or gender did not help predict how many life science courses they took in high school.

Do Adolescents' Career Goals Differ by Cluster and Gender? In the previous section, we tested whether high school courses differed by adolescents' self-concepts, values, and gender. Next, we examine the same issues concerning adolescents' career goals: whether adolescents' career goals in twelfth grade were different based on their pattern of beliefs, their

Figure 4.3. Mean Likelihood of Pursuing a Math-Science or Health-Related Career by Ninth-Grade Cluster and Gender



Adolescents rated how likely it would be that they would pursue a career in this field on the following scale: 1 = Very Unlikely to 7 = Highly Likely.

gender, and the interaction between beliefs and gender. We ran the same ANCOVAs that were presented earlier but now tested differences in adolescents' career goals by cluster membership and gender. The means are presented in Figure 4.3 by cluster and gender.

Math-Science Career Goals. Gender, math cluster membership, and science cluster membership predicted significant differences in math-science career goals. As expected, males reported that they were more likely than females to pursue a math-science career ($p < .05$). Findings also suggest that adolescents with high math self-concepts and values (that is, the Both High math cluster) were more likely to believe they would pursue a math-science career than other adolescents (all comparisons significant at least at $p < .05$). The analyses with the science clusters, however, suggest that having a high science self-concept is critical, but having the combination of high science values and self-concepts may not be essential. As in the case of the math clusters, adolescents with high science self-concepts and values were more likely than youth with moderate or low science values to report they wanted to pursue a math-science career (all comparisons significant at least at $p < .05$). However, adolescents in the High Self-Concept science group also had a higher rating of pursuing a math-science career than adolescents in the Both Moderate and Both Low science clusters (all comparisons significant at least at $p < .05$). Thus, adolescents in both science clusters marked by higher-than-average science self-concepts reported that they were more likely to pursue a career in a math-science field than adolescents who had moderate or low science self-concepts and values.

Health Career Goals. Adolescents' endorsement of health-related career goals significantly varied by gender and science cluster membership but not math cluster membership. The significant gender effect revealed that females were more likely than males to report that they would pursue a career in the health field ($p < .001$). The results from the analysis with the science clusters suggest that adolescents with high science values and self-concepts (that is, the Both High cluster) reported a higher likelihood of pursuing a health career than adolescents with moderate or low science values and self-concepts ($p < .01$, $p < .001$ respectively). In addition, adolescents in the High Self-Concept science cluster reported stronger endorsement of pursuing a health career than adolescents in the Both Low science cluster ($p < .01$). The significant interaction between gender and cluster membership revealed that within the High Self-Concept science cluster, females reported a higher likelihood than males of going into a health profession ($p < .001$).

Discussion

Math and science skills are becoming increasingly critical for many jobs in the United States. For example, global competition has resulted in outsourcing many manual labor positions that do not rely heavily on educational achievement. For this and other reasons, jobs located in the United States are becoming more reliant on educational achievement, often in the areas of math, science, and technology. Yet adolescents continue to opt out of the math, science, and technology pipeline. It is important to understand the determinants of adolescents' math and science choices for all youth, but particularly for women, who are traditionally less likely to pursue these domains. Research has shown that gender differences in college and career pathways date back to high school choices. In the study we report in this chapter, we found that differences in adolescents' high school choices date back to their self-concepts and values in ninth grade.

Do Adolescents Vary in Terms of Their Ninth-Grade Self-Concepts and Values? When people make decisions concerning their course work or career, they weigh the perceived costs and benefits associated with the various outcomes. According to the Eccles et al. Expectancy Value Model, two of the key factors adolescents contemplate when making a decision are their self-concept of their abilities in an area and how much they value an area. While adolescents simultaneously consider their self-concept of their abilities and values during the decision process, researchers have typically examined them separately. In the first part of this chapter, we identified groups of adolescents who varied based on their self-concepts of abilities and values. Using these groups rather than self-concepts of abilities and values separately to predict high school choices enabled us to more accurately reflect adolescents' decision process.

This issue is important because much of the previous research linking self-concepts and values to choices has examined each belief separately (Eccles (Parsons) and others, 1985; Jacobs, Finken, Griffin, and Wright, 1998). Yet researchers have theorized that youths' self-concepts and values are linked (Eccles, 1994; Harter, 1986, 1993; Jacobs and others, 2002). Harter, for example, posited that values are shaped by self-concepts, such that adolescents are unlikely to value a subject or domain if they do not believe they have skills in that domain. Children's overall self-esteem is likely to suffer if they believe they do not have skills in a domain they value. As a result, self-concepts and values are likely to keep in check with one another for healthy adjustment. Jacobs and others (2002) found support for this notion by providing longitudinal evidence that declines in self-concept explained declines in values across three different domains.

Our findings suggest that there are unique groups of adolescents who differ in terms of the patterns of self-concepts and values. We identified four unique groups in math and in science: Both High (high self-concept and value), High Self-Concept (high self-concept, moderate or low value), Both Moderate (moderate self-concept and value), and Both Low (low self-concept and value). What is immediately evident is that self-concepts of abilities and values were similar in all of the clusters except the High Self-Concept cluster. In other words, most adolescents believe they have high skills in an area, but only if they also place high value on the area or vice versa. Furthermore, self-concept of ability was usually slightly higher than values for almost all clusters. It is less common for adolescents to value a subject or domain, such as science, when they do not feel they are good at it (that is, they have a low self-concept). Our findings support Harter's notion concerning the consistency between values and self-concepts. If values fluctuate based on youths' self-concepts as Harter theorized, this would suggest that adolescents' self-concepts would first need to change with values following suit.

Do These Various Subgroups Make Different Math and Science Choices? The second key finding from this study is that adolescents who have higher-than-average self-concepts in either math or science are more likely than adolescents with moderate or low self-concepts and values to take math and physical science courses in high school. Adolescents in the two clusters with high self-concepts (that is, the Both High and High Self-Concept clusters) differed in terms of whether they had high or moderate values, but they were similar in terms of the number of courses they took. This suggests that high self-concept is the important determinant of course selection rather than the unique combination of high self-concept and high values.

High self-concepts may be enough to motivate adolescents to take high school courses, but it appears that the combination of high self-concepts and values is important to increase the likelihood of pursuing a career, particularly in math-science fields. The importance of values is also supported in Chapter Three by Watt, who finds that valuing an area is critical for pursuing it in the future. For instance, our results show that adolescents in the cluster with higher-than-average self-concepts and values in math reported higher intentions to pursue a math-science career than any of the other three groups. Adolescents may need to feel they are good at and value a domain to motivate them to pursue that area as a long-term career. The differential importance of this combination for course selection and goals would not have been evident had we not examined the patterns of self-concepts and values.

What Were the Similarities and Differences Between Males and Females? This volume describes gendered pathways in courses, degrees, and careers. We found that gender differences did not favor males in course selection. Females and males enrolled in a similar number of physical science courses. Moreover, females were slightly more likely than males to take life science and math courses (André, Whigham, Hendrickson, and Chambers, 1999; Farmer, Wardrop, Anderson, and Risinger, 1995). Perhaps gender differences did not emerge in adolescents' course selection because adolescents take multiple math and science courses to achieve different college and career goals. In our data, females were more likely than males to want to pursue a career in the area of health and less likely to pursue a career in math-science. As a result, females may take physical science courses as part of their goals to pursue a career in a health-related field. Males may take the same courses to achieve their goals to be a scientist or engineer. Future work should examine the differences in course selection by males and females in science to see if the pathways for life sciences versus physical sciences are being determined in high school and thus contributing to the gender gap found in college-level engineering and computer science majors.

It is encouraging that course selection and the relations between beliefs and choices are similar for males and females in our study and others

(Simpkins, Davis-Kean, and Eccles, forthcoming). The lack of gender differences in associations between beliefs and choices suggests that if males and females have similar math and science self-concepts and values, they are equally likely to pursue those areas in the future. The interesting difference is that fewer females have high science self-concepts and values than males. Thus, although adolescents who have high math and science self-concepts and values are more likely to enroll in additional courses than adolescents with lower beliefs regardless of gender, females are less likely to have high beliefs than males. An important next step is to investigate the precursors of the beliefs adolescents hold at the beginning of high school.

In some of our other work, we have shown that adolescents' beliefs in ninth grade are likely to result from out-of-school activity participation, previous experiences, and contextual influences such as parents (Simpkins, Davis-Kean, and Eccles, forthcoming). Parents and educators need to address children's beliefs about math and science in elementary school and not wait until these youth enter high school. There are numerous influences on youths' beliefs and choices, and these beliefs shift and change across development (Eccles, 1994; Jacobs and others, 2002; Simpkins and others, forthcoming; Updegraff, Eccles, Barber, and O'Brien, 1996). It would be prudent to address youths' performance, self-concepts, and values in math and in science in order to have the largest impact on their later choices. Due to the changes in youths' beliefs across time, an intervention with the largest impact will need to periodically address changes in youths' beliefs.

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