New Directions for
Child and Adolescent
Development

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

Janis E. Jacobs
Sandra D. Simpkins
EDITORS

Number 110 • Winter 2005
Jossey-Bass
San Francisco

LEAKS IN THE PIPELINE TO MATH, SCIENCE, AND TECHNOLOGY CAREERS
Janis E. Jacobs, Sandra D. Simpkins (eds.)
New Directions for Child and Adolescent Development, no. 110
Reed W. Larson, Lene Arnett Jensen, Editors-in-Chief

Microfilm copies of issues and articles are available in 16mm and 35mm, as well as microfiche in 105mm, through University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, Michigan 48106-1346.

ISSN 1520-3247 electronic ISSN 1534-8687

NEW DIRECTIONS FOR CHILD AND ADOLESCENT DEVELOPMENT is part of The Jossey-Bass Education Series and is published quarterly by Wiley Subscription Services, Inc., a Wiley company, at Jossey-Bass, 989 Market Street, San Francisco, California 94103-1741. Periodicals postage paid at San Francisco, California, and at additional mailing offices. Postmaster: Send address changes to New Directions for Child and Adolescent Development, Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741.

New Directions for Child and Adolescent Development is indexed in PsycInfo, Biosciences Information Service, Current Index to Journals in Education (ERIC), Psychological Abstracts, and Sociological Abstracts.

SUBSCRIPTIONS cost $90.00 for individuals and $220.00 for institutions, agencies, and libraries.

EDITORIAL CORRESPONDENCE should be e-mailed to the editors-in-chief: Reed W. Larson (larsonr@uiuc.edu) and Lene Arnett Jensen (jensenl@cua.edu).

Jossey-Bass Web address: www.josseybass.com

5

For middle and high school girls in high-ability math classes, interest and self-concept made a difference for school grades, and for all adolescents, maternal expectations were influential in predicting math grades over time.

The Slippery Slope: What Predicts Math Grades in Middle and High School?

Miriam R. Linver, Pamela E. Davis-Kean

Recently there has been renewed debate on the controversial issue of gender differences in math aptitude and achievement. Although women have made great strides in the law, medicine, biological sciences, and social science professions, they have made less progress in graduate programs and professions linked to computer science, physics, engineering, and information technology jobs (Eccles, 2001). Aptitude for math has long been considered a defining difference between men and women, with men having higher standardized achievement scores on SAT and GRE math exams (Halpern, 2004). Yet the most comprehensive reviews have shown very few differences in math aptitude between males and females (Halpern, 2000, 2004). Indeed, research has demonstrated only one gender-consistent difference between men and women in math aptitude and that involves three-dimensional mental rotation (favoring men). Similarly, other research has demonstrated a decline in gender differences in math performance on standardized tests, suggesting that the more math and science women are exposed to in school, the better their scores are (Hyde and McKinley, 1997). Although this research raises doubts about whether gender differences still

This chapter was funded by a grant (ITWF Award 0089972) from the National Science Foundation to Jacquelynne S. Eccles and Pamela E. Davis-Kean and the NICHD Research Network on Child and Family Well-Being. We thank all the people who participated in data collection for this project, especially the families and children who completed many years' worth of surveys.

exist between males and females in math ability, many researchers still find differences in performance and the interest that males and females have in areas related to math as well as early academic choices involving math course selection in high school (Farmer, Wardrop, and Rotella, 1999; Linver and Davis-Kean, 2004; Jacobs, Finken, Griffin, and Wright, 1998).

Many explanations have been put forth as to why high-achieving women may not be entering math-related professions, including discrimination, gender-typed socialization, low academic self-concept, and the value and interest that women have in these professions (Eccles, 2001). Researchers examining beliefs such as self-concept of math ability, for example, have consistently shown a concrete link between self-concepts in various academic subjects (including mathematics) and career choices (Betz and Fitzgerald, 1987; Betz and Hackett, 1986). The research suggests that adolescents who have a higher self-concept of math ability may choose to take advanced mathematics courses in high school, leading to a potentially greater choice of careers as an adult. Similarly, work by Eccles and colleagues found that gender differences in enrollment in advanced mathematics courses in high school are mediated by gender differences in expectations for success in math and perceived value of competence in math (Eccles, Wigfield, and Schiefele, 1998; Eccles, Barber, and Jozefowicz, 1999). In other words, high school boys and girls enroll in different advanced courses depending on their different expectations for success in math, as well as the value they place on competence in math.

In addition to differences in the types of mathematics courses selected by adolescent males and females, adolescents' interest in math and self-concepts of math ability change over time. Jacobs and others (2002), for example, found that perceived competencies in math decline for both sexes between first and twelfth grades; although in first grade the males had higher math competencies, their self-concepts declined faster, thus leading to no difference between male and female math competencies by twelfth grade. Interestingly, this research also showed that the females valued math more than the males did by twelfth grade, suggesting that females should be equally likely to choose math-related careers or majors in college. Yet this is not the case, and it is unclear if interest, self-concept of ability, achievement, or some combination of these factors is leading to this slippery slope or the decline that is seen in math-related career interest as females enter young adulthood.

In order to understand the complicated interplay between achievement beliefs and performance, we rely on the expectancy-value model developed by Eccles (Parsons) and others (1983). This model posits that choices such as course enrollment and occupational selection depend on individuals' confidence in their ability to succeed in these courses or careers, and on the value the individuals attach to success in these courses and careers (Eccles, 1983; Parsons (Eccles), Adler, and Kaczala, 1982; Wigfield and Eccles, 1992). According to this model, beliefs regarding academic ability and achievement potential are influenced by past performances, how difficult the task is assumed to be, and contextual factors, including socializing information and experiences provided by other individuals. Thus, the model would suggest that the development of self-concept and interest in an individual has both an internal component (one's own beliefs) and an external or socializing agent (others' beliefs about one's ability) that influences belief formation over time. Research suggests, for example, that parents' education and expectations are important predictors of school achievement (Davis-Kean, 2005; Linver, 1998; Linver and Davis-Kean, 2004) and the development of children's own self-concept (Davis-Kean, Eccles, and Schnabel, 2002; Davis-Kean, Peck, and Eccles, 2004; Halle, Kurtz-Costes, and Mahoney, 1997). Thus, in order to see what influences women's career choices, it is important to understand the influence that socializing agents such as parents and teachers have on the formation of math interests and beliefs in women.

As important as parents are in helping adolescents make choices regarding course selection in high school, school policies such as ability tracking also play a large role in the range of options available to students. For example, students often have restricted choices in the type of math classes they are eligible to consider (for example, consumer math versus trigonometry). Research on ability grouping suggests that tracking by ability can affect school grades, interest, and self-concept. For example, Webb, Nemer, and Zuniga (2002) found that being in a homogeneous science classroom with other high achievers is associated with higher grades among high-achieving eighth-grade students. Similarly, self-concept can also be affected, although this effect differs by gender. For girls, being in a low-ability science track is associated with a lower self-concept of science ability, while being in a high-ability science track is associated with higher self-concept (Catsambis, Mulkey, and Crain, 2001). For boys, the opposite is true for math outcomes: high math track was associated with lower self-concept and low math track with higher self-concept of math ability. The finding for boys supports what Marsh and colleagues have called the "big-fish/little-pond" effect, where boys have higher self-concept when they perform well compared to others (Marsh, Chessor, Craven, and Roche, 1995). One explanation for the opposite finding for girls in science is that girls are more responsive to actual achievement rather than socially comparative feedback. Knowing one is in a high-track math class may be sufficient evidence that one has high math ability for girls. Because ability grouping can have differential effects on males' and females' math school grades, interest, and self-concept, we examine math school grades separately by both gender and math ability groups.

Based on previous research and potential pathways and influences described in the Eccles et al. Expectancy Value Model, this chapter examines school grades over time by gender and ability groups. We address the following questions:

- What is the average trajectory for school grades from seventh grade through high school by gender and by school ability track?
- Will interest and self-concept of ability predict to grades over and above the contextual socializing influences of mothers' and teachers' expectations?
- Do these predictors differ for young women and young men, and for those in high versus low math ability tracked classes?

Method

We examined data from a large longitudinal study of adolescents and selected variables that could best answer our three research questions. We used a sophisticated analytical technique, latent growth curve modeling, described in detail at the end of this section.

Data and Sample. Data come from the Michigan Study of Adolescent Life Transitions (MSALT), an eighteen-year longitudinal project; the same adolescents participated at nine separate occasions (waves) over the eighteen years. MSALT was originally designed to examine the impact of school transitions and family environments on early adolescents' interest, motivation, and achievement-related self-concepts (see Barber, Eccles, and Stone, 2001; Eccles and others, 1989; Eccles, Barber, and Jozefowicz, 1999). The subsample examined in this chapter encompassed 1,651 adolescents, for whom data are available from seventh to twelfth grade. The sample was 54 percent female. Adolescents were predominantly white (92 percent) and from working- and middle-class families.

Measures. Measures in the study were contextual measures, school grades, math interest, self-concept, standardized test score, and math class track.

Contextual Measures. The measures of context were mothers' education, mothers' expectations, and teachers' expectations. Higher scores for all these measures indicate higher education level and higher expectations. Mothers' expectations of their adolescents' success in math were measured at seventh grade and assessed with the open-ended question, "What grade in math do you expect your child to get this term?" The mean expected grade was a *B*. To control for initial levels of motivation, we included the teachers' expectations of students' abilities in math class in seventh grade.

School Grades. School grades in math were collected from school record data every semester in sixth, seventh, ninth, tenth, and eleventh grades. A mean of both semesters was used for each grade level. A higher score on the school grades scale indicates a higher grade (where *A* is the highest).

Math Interest, Self-Concept, and Standardized Test Score. Adolescents' interest in math was assessed in the fall and spring of sixth grade with the following question: "How much do you like doing math?" Self-concept of math ability was also measured in the fall and spring of sixth grade.

Students were asked, "How good at math are you?" For both math interest and self-concept, the responses at both sixth-grade time points were averaged to form sixth-grade means; higher scores correspond to higher interest and self-concept of ability. A standardized math test, the Michigan Educational Assessment Program (MEAP), was administered in seventh grade. Gender was coded as 1 = female and 0 = male.

Math Ability Track. In a previous study using MSALT data, diverse individual course enrollment patterns were inspected to estimate the level of sequence of math courses students took across the four years of high school (Updegraff, Eccles, Barber, and O'Brien, 1996). Most of the students followed the sequences recommended in their high school handbooks—that is, sequences linked to either their math ability level or their post–high school occupation trajectories. Students were classified into one of four tracks based on their ninth-grade math course and information in their high school handbook: honors, college, regular, and basic.

Honors students typically took geometry in ninth grade, algebra or trigonometry in tenth grade, precalculus in eleventh grade, and calculus in twelfth. The college group commonly chose algebra, geometry, algebra II or trigonometry, and precalculus (or no math) in ninth through twelfth grades, respectively. The regular group was enrolled in prealgebra in ninth grade, algebra I in tenth, geometry in eleventh, and no math in twelfth grade. Finally, those classified into the basic track were commonly enrolled in general math in ninth grade, general math or prealgebra or algebra in tenth grade, and no math in eleventh or twelfth grades. In analyses for this chapter, honors and college ability groupings were combined into a high-track category (56 percent of the sample), and regular and basic were combined into a low-track category (44 percent) in order to streamline analyses. With two ability tracking groups, there are four analysis groups in total, because we examine grades separately for tracking group and gender.

Analysis Plan. A latent growth curve (LGC) modeling technique was used to estimate adolescent math school grades from middle school (seventh grade) through high school. This technique involves estimating the two components of a curve, the intercept and slope, as latent constructs (Duncan and others, 1999). The intercept refers to the value at the starting point of the curve; in this study, the starting point is math school grades at seventh grade (earlier and concurrent data are used to predict to this intercept). The slope refers to the change over time. For example, if the slope of math school grades is negative, this translates into a decline in school grades from middle school through high school; if the slope is zero, this means school grades remain constant, not changing over time. By estimating both intercept and slope as latent constructs in LGC models, we are able to predict to the intercept and slope as dependent variables, entering controls and contextual variables into our models as predictors. We can also use LGC models to examine differences by gender and ability groups by estimating different models for each group. LGC analyses were performed using the Amos (Analysis of Moment Structures) program (Arbuckle and Wothke, 1999).[1]

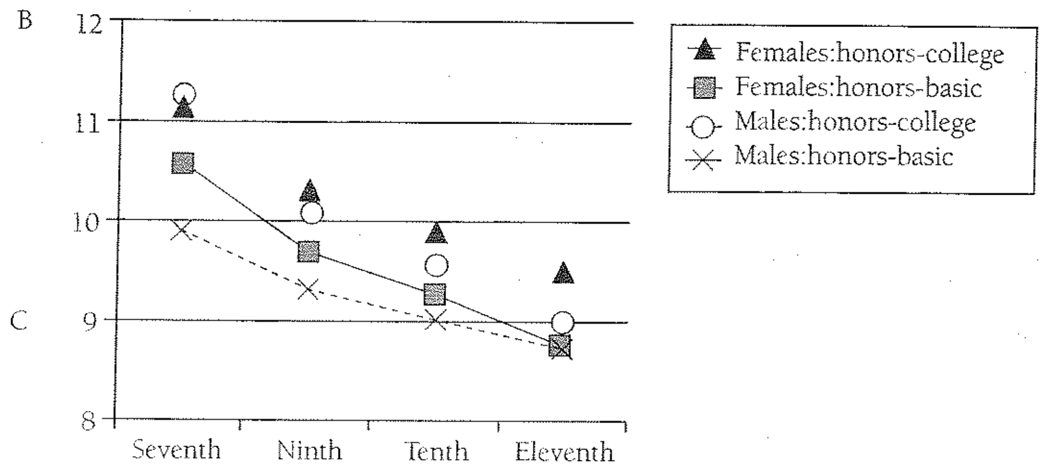
In our analyses, the dependent variable is school grades. The intercept of the growth curve is school math grades at seventh grade. The slope of the growth curve encompasses change in math school grades from seventh to eleventh grades.[2] We first examined the mean of math school grades across all time points to assess the general direction of curve. Next, we estimated LGC models for math school grades, predicting change in math school grades over time from math interest and self-concept, while controlling for middle school maternal and teacher contextual predictors as well as math ability. We examined models separately by ninth-grade math track (those in the honors and college tracks were compared to those in the regular and basic tracks) and by gender, so there were four groups in total.

Results

School grades declined for every group between middle school and high school. We conducted *t*-tests to determine if math school grade differences were significantly different by gender and tracking group. Adolescent females in the honors-college group had the highest grades. Their math school grades were higher than all other groups (for sixth and seventh grades); the girls' grades, however, were not significantly different from the boys' math school grades in the honors-college group in grades 9 and 10 but were higher than both genders' math school grades in the regular-basic group (ninth, tenth, and eleventh grades). Math grades can be represented by a slippery slope with declines for all groups over time. When examining school grades without controlling for other influences (such as mothers' and teachers' expectations, previous achievement, and interest and self-concept of ability), adolescent girls in the higher tracking group had the highest grades.

Do previous performance and parents' and teachers' expectations influence school grades? To answer this question, we estimated LGC models for each gender and ability tracking group, controlling for previous performance as well as parent and teacher influences. Figure 5.1 illustrates the adjusted mean math school grades from seventh to eleventh grades by track (honors-college versus regular-basic) and gender. Overall, adolescent women had slightly higher grades than adolescent men (within each tracking group). For both adolescent men and women in the honors-college track group, mean-level math grades start out fairly high (around a B or B−) and then decline throughout high school, ending at about a B− or C+. For students in the regular-basic math track, the intercept of math grades was lower (about a B− or C+) and ended lower, at about a C. Even when taking into account contextual predictors and math achievement, math school grades can still be described by a slippery slope, declining for both genders by tracking group between middle school and high school.

Figure 5.1. Math School Grades from Seventh to Eleventh Grade by Gender and Ninth-Grade Math Track



Note: Controlling for all maternal, teacher, and adolescent variables.

The LGC analysis allowed us to predict differences in grades at seventh grade (intercept) and change (slope) over time in each group's math grades. Table 5.1 presents the overall differences and change for each group, as well as which predictors or influences were associated with the differences at seventh grade and the change from seventh to eleventh grade in math school grades for both genders by math ability tracking groups. Only significant predictors (based on the critical ratio, interpreted as a *t*-score where 1.96 and above is significant at the $p < .05$ level) are listed for each group.

Some findings were parallel across all four gender and tracking groups. In particular, there were many similar predictors of school grades intercept. As expected, sixth-grade school grades were related to school grades at seventh grade; in fact, because sixth-grade math school grades are included in all models, we can interpret all other variables as predicting math grades over and above the effects of earlier school grades. Also as expected, those with higher MEAP scores had higher math grades in seventh grade for most gender-by-tracking groups; again, inclusion of this control allows us to interpret any other findings net of this relation between math achievement score and school grades. Mothers' educational expectations for their children were associated with math grades intercept. The significant relation of this socialization variable confirms previous research demonstrating that mothers' expectations are indeed important for adolescents' performance in school, in that higher expectations are associated with higher grades at seventh grade. And given that earlier school grades and math achievement score are controlled, mothers' expectations are important even after taking into account students' previous achievement. Below, unique results are discussed separately for each gender and tracking group.

Table 5.1. LGC Models: Predictors of Intercept and Slope of Math School Grades by Gender and Tracking Group

	Estimate	*SE*	*Critical Ratio*	*Squared Multiple Correlation*
Math school grades intercept				
Females, honors-college	11.148	0.115	97.068	0.780
Females, remedial-basic	10.597	0.163	64.911	0.880
Males, honors-college	11.256	0.110	102.322	0.776
Males, remedial-basic	9.910	0.214	46.210	0.716
Intercept predictors, by gender/tracking groups				
Females, honors-college				
Sixth-grade math grades	0.237	0.063	3.739	
Seventh-grade math MEAP	0.092	0.044	2.094	
Seventh-grade mother's expectations	0.627	0.057	10.961	
Seventh-grade teacher rating	0.258	0.090	2.876	
Females, remedial-basic				
Sixth-grade math grades	0.210	0.074	2.855	
Seventh-grade mother's expectations	0.642	0.064	10.061	
Males, honors-college				
Sixth-grade math grades	0.181	0.063	2.870	
Seventh-grade math MEAP	0.134	0.044	3.044	
Seventh-grade mother's expectations	0.635	0.043	14.799	
Males, remedial-basic				
Sixth-grade math grades	0.358	0.075	4.755	
Sixth-grade math self-concept	−0.388	0.138	−2.820	
Seventh-grade mother's expectations	0.451	0.064	7.069	
Math school grades slope				
Females, honors-college	−0.418	0.051	−8.227	0.193
Females, remedial-basic	−0.454	0.064	−7.130	0.684
Males, honors-college	0.571	0.046	12.388	0.163
Males, remedial-basic	−0.300	0.090	−3.346	0.106
Slope predictors, by gender and tracking groups				
Females, honors-college				
Mother's education	0.122	0.048	2.561	
Sixth-grade math self-concept	−0.074	0.038	−1.939	
Sixth-grade math interest	0.071	0.024	2.940	
Seventh-grade mother's expectations	−0.083	0.030	−2.809	
Females, remedial-basic				
Seventh-grade mother's expectations	−0.176	0.030	−5.946	
Males, honors-college				
Mother's education	0.132	0.050	2.635	
Seventh-grade mother's expectations	−0.105	0.022	−4.876	
Males, remedial-basic [none]				

Note: None of the predictors in the model for males in remedial-basic individually explained a significant amount of variance in the change of math grades over time.

Females in the Honors-College Group. Did previous achievement and parent and teacher influences on high-ability females have an impact on grades? Females in the honors-college group had fairly high grades at seventh grade, but did not look significantly different from males in the honors-college group. Previous achievement and parent and teacher influences were found to be important predictors of seventh-grade performance; the squared multiple correlation (R^2) indicates that 78 percent of the variance in the intercept was predicted by the predictors in the model. Grades for this group declined significantly over time, but not as quickly as grades for females in the regular-basic group or as males in the honors-college group. A significant portion of the variance in the changes in grades (19 percent) was explained by previous achievement and parent and teacher influences. Even after predictors were added to the model, this group still had high grades at seventh grade, and their grades declined significantly over time. Achievement and contextual variables predicted a significant amount of the variance. Which of these were significant predictors of the math grades intercept and slope?

For females in the high-ability tracking group, one predictor was significantly related to intercept beyond the predictors discussed. In addition to maternal expectations, higher teachers' expectations were also related to higher seventh-grade math grades. Interest in math and self-concept of math ability were not associated with math grade intercept for this group. Those with higher math aptitude and those who had done well in past math courses not surprisingly had high math grades in seventh grade. But expectations of people important in the adolescent's life (such as mother and teacher) also played a role in school grades; regardless of math grades and attitudes, higher expectations were important for higher girls' math grades in this tracking group.

Several predictors were also significantly associated with this group's slope of math school grades. In particular, two socialization variables (mother's education and mother's expectations), as well as earlier (sixth-grade) interest in math and math self-concept of ability were significantly related to change in math grades from seventh grade to eleventh grade. Note that the slope of school grades is negative, indicating a decline in grades over time. If a predictor is positively associated with a negative slope, this means that as the level of the predictor level increases, the slope will be more negative (that is, it will decrease more quickly). If the predictor is negatively associated with a negative slope, the effect is the opposite: a higher value of the predictor variable is associated with a less negative slope, so it will decrease more slowly. Keeping this in mind, two of the significant predictors of slope had a positive relation, and two had a negative association. Mother's education level was associated positively with the declining slope; those whose mothers had a higher level of education had a more quickly declining slope. And those whose mothers had a higher degree of expectations for their children's math grades had slopes that declined more slowly.

For the slope, both achievement and socialization variables were not always related to change in grades in a predictable way. In particular, higher interest was associated with a more quickly declining slope, as was higher mother's education level. Because interest and self-concept are related to each other, self-concept of math ability may be absorbing the majority of the effect on declining grades (known as multicollinearity), so it could be seen as a statistical artifact that higher interest in math is related to a more quickly declining slope. An alternative explanation for this anomalous finding is that girls may begin to feel pressure to excel in nonmath arenas, conceding to stereotypes that may compel some girls in the high-ability grouping to do less well in math despite their high math interest.

Females in the Regular-Basic Group. Do females in the lower tracking group look similar to those in the high tracking group? For females in the regular-basic ability tracking group, the intercept of math grades was lower than for females in the higher tracking group, and the slope fell more quickly. Much of the variance for both intercept and slope was explained by the LGC model: 88 percent of the variance in intercept and 68 percent in slope. As with females in the higher-ability tracking group, self-concept and interest were not associated with math grades intercept. In terms of initial-level (seventh-grade) math grades, this group looks similar to the higher tracking group: both achievement and contextual-level variables are important in predicting seventh-grade math grades.

Only one variable was associated with the declining slope for females in the regular-basic group: seventh-grade mothers' expectations were negatively related to declining grades, indicating that higher mothers' expectations for this group were associated with a slower decline in school grades through high school. Across both female tracking groups, self-concept and interest were not related to initial level of math grades. For those in the higher tracking group, higher self-concept of math ability protected girls' math grades through high school, whereas for girls in the lower tracking group, self-concept was unrelated to math grades slope. Although it was surprising to us that interest and self-concept were not related to seventh-grade math grades, it may be that in middle school, where most students take the same math classes, parental expectations and previous math ability play a stronger role in how well girls do in math classes. Throughout high school, where students split into different math class tracks, those in the higher tracks may place more weight on their own abilities. Having a high self-concept may enhance motivation to perform well, leading girls who have been labeled as good in math by being in a higher track to have grades that decline more slowly over time.

Males in the Honors-College Group. What accounts for school grades for males in the high-ability tracking group? The intercept of math school grades was highest for males in the honors-college group compared to the other groups, although the slope value indicates that the grades of this group declined most quickly. As with females in the honors-college ability tracking group, the LGC model explained much of the variance in the intercept (78 percent) and a significant but lower proportion of the slope variance (16 percent). Interestingly, teachers' expectations did not make a difference; males' grades did not depend on the expectations of their teachers, unlike for girls in the high-ability tracking group. Mothers' expectations were important for both boys and girls in the high tracking group.

The only predictors of the math grades slope for males in the honors-college group were contextual: mother's education level and expectations were associated with declining grades over time. As with females in the honors-college group, mother's education level was positively associated with declining slope (higher maternal education was associated with a more quickly declining slope of school grades), but mother's expectation level was negatively related to the slope, indicating that higher expectations were associated with a slope that declined less over time. Again, this difference may be due to multicollinearity of the maternal variables. Contrary to expectations, self-concept of math ability and math interest were not related to either intercept or slope for high-ability males.

Males in the Regular-Basic Group. Males in the regular-basic group look very different from the other gender and ability-level groups. First, the intercept of school grades was much lower than for the other three groups, although the model similarly predicted a good deal of variance in the intercept (72 percent). The slope, though, was much less steep compared to the other groups (possibly because these young men started out with much lower grades so did not have as far to slide), but the model did not explain much of the variance in slope (11 percent). Beyond variables associated with intercept for all the groups, self-concept of math ability in sixth grade was negatively associated with intercept. This finding indicates that those with a higher self-concept of their math ability had even lower grades in seventh-grade math classes compared to other males in the regular-basic group. This finding could be due to multicollinearity as before. Or it could be due to the fact that these boys are in the lower-ability tracking group. So if they have a higher self-concept of math ability, they may feel they are not taking courses that are challenging enough and may withdraw their effort from the math courses, resulting in lower grades. Although overall the model predicted 11 percent of the variance in slope, no individual predictors in the model were significant predictors of change in math grades over time for males in the regular-basic group. Our model, then, was not a good one for predicting the declining grades of boys in the lower-ability group.

Looking at males in both tracking groups, math interest and self-concept were generally unrelated to math grades either at seventh grade or across time (barring the anomalous finding for males in the lower tracking group discussed above). There are several possible interpretations of this finding. First, we may conclude that past achievement and maternal expectations are more important for boys' math grades than their own self-concept of math ability or interest in math. An alternative interpretation is that boys' grades are not as sensitive to their own self-concept of ability or their interest in math compared to girls' grades. Having interest and self-confidence in a particular subject may lead to doing better in this subject, but this relation may be operating only for girls. This interpretation is consistent with the work of Catsambis, Mulkey, and Crain (2001), who found that being in a higher track is associated with higher self-concept of ability for girls but not for boys.

Conclusion

We found that both initial math grade level and rate of grade changes are different depending on the adolescent's gender and tracking group. Girls and boys in the high-ability tracking group had the highest grades at seventh grade; boys in the low-ability tracking group had the lowest grades. Although all groups' grades declined over time, girls in the high tracking group had the highest grades by the end of high school. This finding of declining grades is similar to what others have found (Jacobs and others, 2002). One unique aspect of this study, though, is our approach to carving out groups of adolescents.

Girls' comparable (at seventh grade) and higher (through high school) math grades compared to boys' grades, as seen in Figure 5.1, are consistent with recent work by Halpern (2004). Thus, it is not girls' math grades that are likely to be responsible for the gender difference in pursuit of careers in physical science and information technology. Instead, as predicted by the Eccles et al. Expectancy Value Model, the gender differences in self-concepts, not in school grades, are likely to be the strongest influences on the gender differences in career pursuits. Our study supports the model, as we found gender differences in self-concept of math ability and math interest. These constructs were associated with school grades for high-ability girls but not for other groups.

We found that the downward slope for grades differed by gender and ability grouping. Boys in the low-ability grouping had the lowest grades at seventh grade so did not have as far to fall. Other groups' slopes were much steeper; girls in the high-ability grouping, however, had the least slippery slope compared with boys in the high-ability group and girls in the low-ability group. Higher math interest was related to a more quickly declining slope; this finding may be due to either the statistical artifact of multicollinearity or the fact that high-achieving girls may be coerced by the pressure of gender-stereotyped behavior. In other words, although girls in the high tracking group may have high interest in math, this interest may be subjugated by the societal pressures that girls are not supposed to be interested in math. For girls in the high-ability group, however, higher self-concept of ability was related to a less steep decline in grades over time for girls in the high tracking group. Thus, for the high-ability girls, having a higher self-concept of math ability acted as a protective factor against grade decline and contributed to the slowing of the grade decline throughout high school.

Mothers exerted a strong influence on adolescents' grades from middle school through high school. This compelling finding was somewhat surprising. Although prior research suggests maternal education and expectations are important predictors of adolescent achievement-related constructs, we thought we would find stronger effects from individuals' own interest and self-concept in the prediction of grades. We did find these individual characteristics to be important for the change in honor-college females' grades over time but not for the males' grades. In general, our models were better at predicting females' than males changes in math grades over time. Both the individual and contextual predictors we focused on (previous grades, interest, and self-concept; math achievement score; maternal education and expectations; teacher ratings) were more salient for girls than for boys. For the boys, the contextual factors were more influential in the change in grades over time. Perhaps for school achievement, some adolescents have internalized their mother's expectations for them. The pervasiveness of maternal influence is reflected in the robustness of this finding across all gender and tracking groups.

Interestingly, mother's education tended to have a negative influence on grades over time. We found that the higher the mother's level of education, the more quickly the grades decreased over time. However, this finding should be viewed cautiously since this variable is entered into the model with maternal expectations for achievement, and these two factors are highly related (Davis-Kean, 2005). It is possible that the influence of maternal expectations may be suppressing the positive effect of mother's education on adolescents' school grades in the models.

Our findings suggest that in order to encourage more women to choose math or math-related fields such as computer science, interventions need to be designed that focus not only on the academic achievement of women but on the potential contextual influence of the parents as well as early interest and self-concept. The parental influence could be very important in instilling early interest in math activities and later course selection for girls (Simpkins, Davis-Kean, and Eccles, forthcoming). For boys, the parental influence is important for their sustained grades over time. Here it is possible that boys already have high interest and self-concept in math, as we have found in other research (Linver and Davis-Kean, 2004). However, having mothers with high achievement expectation might translate into more work with boys on homework or other home activities (see Davis-Kean, forthcoming) that might help with sustaining achievement over time. Thus, any future interventions focusing on school math grades should include not only components that focus on adolescents, but also elements that draw in parents to facilitate interest and achievement in math across both middle school and high school years.

Notes

1. Amos allows models to be estimated even when there are some missing data (Kline, 1998) and uses the preferred maximum likelihood method for estimating parameters (Bollen, 1989) by calculating a log function of the model parameters from the raw data (Arbuckle, 1996; Bollen, 1989; McArdle and Hamagami, 1996). All predictors were mean centered before being entered into the growth models, indicating that the sample means were subtracted from each score, making the mean equal to zero. Thus, the variance component for growth curve means had a consistent interpretation across models (Jacobs and Osgood, 2002).

2. In our analyses, we could include only math grades between seventh and eleventh grades in school (even though twelfth-grade school grades were available), because by definition, those in the regular group did not take math courses in twelfth grade and those in the basic group did not take math courses in eleventh or twelfth grade.

References

Arbuckle, J. L. "Full Information Estimation in the Presence of Incomplete Data." In G. A. Marcoulides and R. E. Schumacker (eds.), *Advanced Structural Equation Modeling: Issues and Techniques*. Mahwah, N.J.: Erlbaum, 1996.

Arbuckle, J. L., and Wothke, W. *Amos 4.0 User's Guide*. Chicago: SmallWaters, 1999.

Barber, B. L., Eccles, J. S., and Stone, M. R. "Whatever Happened to the Jock, the Brain, and the Princess? Young Adult Pathways Linked to Adolescent Activity Involvement and Social Identity." *Journal of Adolescent Research*, 2001, *16*, 429–455.

Betz, N. E., and Fitzgerald, L. F. *The Career Psychology of Women*. Orlando, Fla.: Academic Press, 1987.

Betz, N. E., and Hackett, G. "Applications of Self-Efficacy Theory to Understanding Career Choice Behavior." *Journal of Social and Clinical Psychology*, 1986, *4*, 279–289.

Bollen, K. A. *Structural Equations with Latent Variables*. Hoboken, N.J.: Wiley, 1989.

Catsambis, S., Mulkey, L. M., and Crain, R. L. "For Better or for Worse? A Nationwide Study of the Social Psychological Effects of Gender and Ability Grouping in Mathematics." *Social Psychology of Education*, 2001, *5*, 83–115.

Davis-Kean, P. E. "The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment." *Journal of Family Psychology*, 2005, *19*, 294–304.

Davis-Kean, P. E., Eccles, J. S., and Schnabel, K. U. "How the Home Environment Socializes a Child: The Influence of SES on Child Outcomes." Paper presented at the International Society for the Study of Behavioral Development, Ottawa, Canada, Aug. 2002.

Davis-Kean, P. E., Peck, S., and Eccles, J. S. "The Indirect Role of Parental Beliefs and Children's Beliefs on the Prediction of Children's Academic Ability." Paper presented at the International Society for the Study of Behavioral Development, Ghent, Belgium, July 2004.

Duncan, T. E., and others. *An Introduction to Latent Variable Growth Curve Modeling: Concepts, Issues, and Applications*. Mahwah, N.J.: Erlbaum, 1999.

Eccles, J. S. "Expectancies, Values, and Academic Behaviors." In J. T. Spence (ed.), *Achievement and Achievement Motives*. New York: Freeman, 1983.

Eccles, J. S. "Achievement." In J. Worell (ed.), *Encyclopedia of Women and Gender: Sex Similarities and Differences and the Impact of Society on Gender*. Orlando, Fla.: Academic Press, 2001.

Eccles, J. S., Barber, B. L., and Jozefowicz, D. "Linking Gender to Educational, Occupational, and Recreational Choices: Applying the Eccles et al. Model of Achievement-Related Choices." In W. B. Swann Jr. and J. H. Langlois (eds.), *Sexism* *and Stereotypes in Modern Society: The Gender Science of Janet Taylor Spence.* Washington, D.C.: American Psychological Association, 1999.

Eccles (Parsons), J. S., and others. "Expectancies, Values, and Academic Behaviors." In J. T. Spence (ed.), *Achievement and Achievement Motivation.* New York: Freeman, 1983.

Eccles, J. S., Wigfield, A., and Schiefele, U. "Motivation to Succeed." In W. Damon and N. Eisenberg (eds.), *Handbook of Child Psychology, Vol. 3: Social, Emotional, and Personality Development.* (5th ed.) Hoboken, N.J.: Wiley, 1998.

Eccles, J. S., and others. "Self-Concepts, Domain Values, and Self Esteem: Relations and Changes at Early Adolescence." *Journal of Personality,* 1989, *57,* 283–310.

Farmer, H. S., Wardrop, J. L., and Rotella, S. C. "Antecedent Factors Differentiating Women and Men in Science/Nonscience Careers." *Psychology of Women Quarterly,* 1999, *23,* 763–780.

Halle, T., Kurtz-Costes, B., and Mahoney, J. "Family Influences on School Achievement in Low-Income, African American Children." *Journal of Educational Psychology,* 1997, *89*(3), 527–537.

Halpern, D. F. *Sex Differences in Cognitive Abilities.* (3rd ed.) Mahwah, N.J.: Erlbaum, 2000.

Halpern, D. F. "A Cognitive-Process Taxonomy for Sex Differences in Cognitive Abilities." *Current Directions in Psychological Science,* 2004, *18*(4), 135–139.

Hyde, J. S., and McKinley, N. M. "Gender Difference in Cognition: Results from Meta-Analysis." In P. J. Caplan, M. Crawford, J. S. Hyde, and J.T.E. Richardson (eds.), *Gender Differences in Human Cognition.* New York: Oxford University Press, 1997.

Jacobs, J. E., Finken, L. L., Griffin, N. L., and Wright, J. D. "The Career Plans of Science-Talented Rural Adolescent Females." *American Educational Research Journal,* 1998, *35,* 681–704.

Jacobs, J. E., and Osgood, D. W. "The Use of Multi-Level Modeling to Study Individual Change and Context Effects in Achievement Motivation." In P. R. Pintrich and M. L. Maehr (eds.), *New Directions in Measures and Methods.* New York: Elsevier Sciences, 2002.

Jacobs, J. E., and others. "Changes in Children's Self-Competence and Values: Gender and Domain Differences Across Grades One Through Twelve." *Child Development,* 2002, *73*(2), 509–527.

Kline, R. B. "Software Programs for Structural Equation Modeling: Amos, EQS, and LISREL." *Journal of Psychoeducational Assessment,* 1998, *16,* 343–364.

Linver, M. R. "Pathways of Adolescent College Graduation Expectations: Individual and Maternal Predictors." Unpublished doctoral dissertation, University of Arizona, 1998.

Linver, M. R., and Davis-Kean, P. E. "How Did I Get Here? Trajectories of Math Grades, Self-Concept, and Interest by Gender and School Tracking Group." Paper presented at the biennial meetings of the Society for Research on Adolescence, Baltimore, Md., Mar. 2004.

Marsh, H. W., Chessor, D., Craven, R., and Roche, L. "The Effects of Gifted and Talented Programs on Academic Self-Concept: The Big Fish Strikes Again." *American Educational Research Journal,* 1995, *32,* 285–319.

McArdle, J. J., and Hamagami, F. "Multilevel Models from a Multiple Group Structural Equation Perspective." In G. A. Marcoulides and R. E. Schumacker (eds.), *Advanced Structural Equation Modeling: Issues and Techniques.* Mahwah, N.J.: Erlbaum, 1996.

Parsons (Eccles), J. S., Adler, T. F., and Kaczala, C. M. "Socialization of Achievement Attitudes and Beliefs: Parental Influences." *Child Development,* 1982, *53,* 310–321.

Simpkins, S. D., Davis-Kean, P. E., and Eccles, J. S. "The Role of Activity Participation and Beliefs in High School Math and Science Course Selection." *Developmental Psychology,* forthcoming.

Updegraff, K. A., Eccles, J. S., Barber, B. L., and O'Brien, K. M. "Course Enrollment as Self-Regulatory Behavior: Who Takes Optional High School Math Courses?" *Learning and Individual Differences,* 1996, *8*, 239–259.

Webb, N. M., Nemer, K. M., and Zuniga, S. "Short Circuits or Superconductors? Effects of Group Composition on High-Achieving Students' Science Assessment Performance." *American Educational Research Journal*, 2002, *39*, 943–989.

Wigfield, A., and Eccles, J. S. "The Development of Achievement Task Values: A Theoretical Analysis." *Developmental Review,* 1992, *12*, 1–46.

MIRIAM R. LINVER is assistant professor in the Department of Family and Child Studies at Montclair State University, Montclair, New Jersey.

PAMELA E. DAVIS-KEAN is assistant research scientist at the Institute for Social Research and the Institute for Research on Women and Gender, University of