

MATHEMATICS AS THE CRITICAL FILTER: CURRICULAR EFFECTS ON GENDERED CAREER CHOICES

Xin Ma

University of Kentucky, Lexington, USA

Using longitudinal data from the Longitudinal Study of American Youth (LSAY), we examined career choices after each completed mathematics course beginning with the seventh grade, and college major choices in relation to each completed mathematics course in the twelfth grade. Mathematics coursework did have isolated but important effects on the status of students' career and college major choices. Algebra II was identified as a critical filter for the career choices of males, whereas calculus was identified as a critical filter that screened females from science and engineering majors and into majors in liberal arts. Mathematics coursework had no identifiable impact on the career choices of females, and mathematics coursework was secondary to mathematics achievement in terms of the impact on college major choices of males.

UNDERLYING THEORETICAL FRAMEWORK

A successful school-to-work transition is highly contingent on academic training that students receive in school, in particular in the core areas of mathematics and science. Students with limited academic preparation (coursework) in high school are likely to face an extremely difficult path toward workplaces (Bishop, 1996; Wilson, 1996). Mathematics preparation is important to the pursuit of high-status careers. As early as 1973, Sells referred to mathematics as the 'critical filter' that effectively screens students for prestigious careers. She reported that 92% of the first-year female students entering the University of California at Berkeley had such an inadequate number of advanced mathematics courses that they would eventually lose over 70% of career options available to them, most of which were prestigious ones. Stinson (2004) argues that mathematics has been an effective tool for social stratification.

Some factors have been identified in the research literature as having critical influences on students' educational and occupational choices. Working on the basis of Bandura's (1977) self-efficacy theory, Betz and Hackett (1983) developed a theory of career self-efficacy that constitutes an important factor in career choices. In this model, students' sense of career self-efficacy is partly informed by prior educational attainment. Focusing on mathematics-intensive career choices, these researchers argue that mathematics self-efficacy, defined as beliefs about one's ability to perform mathematical tasks, is related to choice of careers in mathematics and science fields. Prior mathematics attainment is the major source of mathematics self-efficacy in their model.

Expectancies and values are also factors that have been shown to influence career choices. The expectancy-value model of academic choice (Eccles et al., 1983) addresses four groups of traits of an individual: (a) perception of the attitudes and expectancies of his or her socializers and his or her interpretations of past experiences; (b) task beliefs, broad goals, and general self-schemata; (c) subjective task values and expectancies for success; and (d) achievement-oriented behaviours such as persistence, choice, and performance. Their relationship sequence is specified as (a) predicting (b), (b) predicting (c), and (c) predicting (d).

We expect that the mathematics coursework participation of high school students is also an indicator of educational and occupational aspirations. Shernoff and Hoogstra (2001) demonstrated a relationship between engagement in high school mathematics and science classes and choice of college mathematics and science majors. Using data from the 1988 National Education Longitudinal Study, Hoogstra (2002) found that the number of advanced mathematics courses taken in high school was predictive of majoring in mathematics and science at the college level, and Kilpatrick (1988) emphasized the importance of taking calculus—the most advanced U.S. high school mathematics course—to planned higher education and future occupation, showing that taking calculus had a strong influence on individuals' choice of undergraduate majors leading to highly prestigious careers.

OBJECTIVES AND SIGNIFICANCE

Our search of the research literature for studies on the effects of mathematics coursework on career and major choices yielded a lack of empirical evidence, highlighting the significance of the present analysis. We focus on differential behaviours of males and females in career and major choices in relation to mathematics coursework. Although many researchers expect such gender differences, the present analysis is among the first investigations that provide direct empirical evidence on this issue, and it holds good potential to fill some critical gaps in the research literature.

Among competing influences, we examine mathematics coursework as our major explanatory variable. Although mathematics coursework has not been emphasized as strongly as mathematics achievement in having critical influences on career and major choices, it may be a critical precursor to mathematics achievement and may demonstrate effect patterns on career and major choices that are different from mathematics achievement. To meaningfully examine the effects of mathematics coursework on career and major choices, it is preferable to control for mathematics achievement as we did in the present analysis.

We focus on gender discrepancies regarding whether change in career and major choices can be attributed to mathematics coursework.

What is the impact of each antecedent mathematics course on subsequent career choices from the seventh grade to the twelfth grade, with control for antecedent career choices, antecedent mathematics achievement, and student characteristics (gender, age, socioeconomic status, race-ethnicity, number of parents, and number of siblings)?

Are there any differences in antecedent mathematics coursework effects on subsequent career choices between males and females from the seventh grade to the twelfth grade?

What is the impact of each mathematics course in the twelfth grade on choices of college or university major, with control for career choices and mathematics achievement in the twelfth grade and student characteristics?

Are there any differences in mathematics coursework effects on college major choices between males and females?

RESEARCH PROCEDURE

We obtained data for the present analysis from the Longitudinal Study of American Youth (LSAY) (N = 3,116). The LSAY started in the fall of 1987 with approximately 60 randomly selected 7th graders from each of 52 schools in a national probability sample. These 7th graders were studied for six years (from grade 7 to grade 12). Students took an achievement test on mathematics and science and completed a student questionnaire in each year. The present analysis used mathematics test and student questionnaire data across all six years.

We derived mathematics coursework indicators from the LSAY composite variable measuring the highest mathematics course that each student took in each grade. In total, students engaged in five different mathematics courses in grade 7, eight in grade 8, ten in grade 9, twelve in grade 10, thirteen in grade 11, and nine in grade 12. We created a number of dummy variables that we referred to as ‘coursework indicators’ at each grade level with no course as the reference against which other courses were compared.

The LSAY mathematics achievement test measured student performance in four domains: basic skills, algebra, geometry, and quantitative literacy. The LSAY staff equated test scores to make these comparable across grades 7 to 12 through the use of item response theory (IRT). We used these mathematics achievement scores as control variables.

Students were asked each year to write in the names of their first and second choice occupations that they expected to pursue. The LSAY staff applied the three-digit occupation codes used by the U.S. Bureau of Census to students’ responses as a way to quantify the prestige of their career choices. This index was comparable across grade levels (grades 7 to 12). We used this index as a continuous dependent variable when we examined the effects of mathematics coursework on career choices.

The LSAY also contained a question on the student questionnaire that asked students in grade 12 what their major would be in college or university. There was a total of 95 university majors. We collapsed them into seven exhaustive categories of majors including science, engineering, economics, law, medicine, liberal arts, and education. We created seven corresponding dummy variables with not attending college or university as the reference against which the seven majors were compared. We used these dummy variables as dependent variables when we examined the effects of mathematics coursework on the selection of university majors.

We used multiple regression techniques to estimate the effects of mathematics coursework on career choices. Cohen and Cohen (1983) discussed three methods to enter independent variables into a regression equation, including the simultaneous method, stepwise method, and block method. Regression using the block method is considered theoretically conservative, statistically rigorous, and practically suitable for explanatory studies, because it ensures that the influence of preceding sets of independent variables is statistically controlled to obtain good validity for a follow-up set of independent variables. The present analysis employed this type of regression technique.

Career choices in each grade were the dependent variable, and career choices and mathematics achievement in the previous grade were used as prior measures (covariates). Prior career choices were entered first into the equation, followed by prior mathematics achievement, the set of student characteristics, and lastly, coursework indicators. The significance of independent variables was determined by the incremental change in R^2 (the variance explained in the dependent variable) for the set, over and above the R^2 for the set(s) entered earlier. This procedure was utilized to adjust the effects of mathematics coursework for prior career choices, prior mathematics achievement, and student characteristics.

Because the choice of a college or university major was a dummy variable, we employed logistic regression techniques to examine the effects of mathematics coursework on majoring in a certain domain (e.g., engineering). Following the same logic of block method, we used grade 12 career choices, grade 12 mathematics achievement, and student characteristics as control variables.

FINDINGS

Negative Mathematics Coursework Effect for Males: Hypothesis of Stumbling Block

We identified a negative coursework effect on the career choices of males who took Algebra II in grade 10, during which period many students undertake this course. This suggests that males might have some eventful experiences in Algebra II that made them consider the need to downgrade their career choices. Could Algebra II lead males to doubt that they could successfully handle the mathematics needed for their desired occupations? We expect that it

could, because males did not experience any negative coursework effect before they reached Algebra II in grade 10, nor did they demonstrate any negative coursework effects after Algebra II in other advanced courses. Males may have unrealistic career expectations before they reach the level of Algebra II. Algebra II in grade 10 may prompt males to put their career expectations into a more realistic perspective. The fact that males did not show further negative coursework effects in more advanced courses after taking Algebra II appears to endorse such thinking—Algebra II is a stumbling block for male career aspirations.

Lack of Mathematics Coursework Effects for Females: Hypothesis of Realistic Aspirations

There was a noticeable lack of mathematics coursework effects for females. For example, while grade 10 Algebra II produced a negative coursework effect on the career choices of males, taking Algebra II or not had no effect on the career choices of females. In fact, females did not experience at all the “fall” from any mathematics course that they undertook during their entire middle and high school years. We hypothesize that females have more realistic career expectations based on a more accurate assessment of their mathematical abilities. We envision that females in mathematics courses have already realistically assessed their mathematical capabilities and accordingly made up their minds regarding their career choices. As a result, females have more stable career choices. This stability could explain the lack of mathematics coursework effects for females.

Females Choosing University Majors: Hypothesis of Calculus as a Powerful Critical Filter

Essentially, mathematics coursework effects on choice of college or university majors consistently highlighted one single mathematics course—calculus. Evidently, calculus functioned as a critical filter for female career choices. Females who undertook calculus in grade 12 were highly *likely* to major in science and engineering, and highly *unlikely* to major in liberal arts. Conversely, without calculus in grade 12, females were not likely to major in either science or engineering but very likely to major in liberal arts. Calculus constrained females’ choice of college majors more seriously than males’. We hypothesize that calculus is a powerful career filter that critically screens females for prestigious occupations. The National Science Foundation (NSF) has recently been emphasizing the importance of attracting many more high school graduates into what is often referred to as “STEM” (science, technology, engineering, and mathematics). We argue from the perspective of mathematics coursework that calculus is a powerful critical gatekeeper that can prevent females from entering the STEM fields.

Males Choosing University Majors: Hypothesis of Achievement as a Better Predictor

In general, we found that mathematics coursework in grade 12 was unrelated to choice of college or university majors for males. On the other hand, mathematics achievement did show some influences on males' college major choices. Higher mathematics achievement was likely to lead males to major in engineering, whereas lower mathematics achievement was likely to lead males to major in liberal arts. Based on the contrast between coursework and achievement effects, we hypothesize that mathematics achievement is a better predictor of college or university majors for males. We suggest that the college major choices of males are more sensitive to mathematics achievement than mathematics coursework.

Retaining Students in Advanced Mathematics Courses

It has been a serious educational challenge in the U.S. (and also elsewhere) to retain an adequate number of students in advanced mathematics courses. The low percent of females who undertook calculus in grade 12 and the importance of calculus for females' college major choices are a worrisome indication that a very limited number of females would enter the STEM field. Retaining many more females in advanced mathematics courses remains a critical educational challenge. One effective method is to change females' attitude toward mathematics—to foster their appreciation of the role of mathematics in their life (Ma, 1997; Vida & Eccles, 2003). Positive attitude toward mathematics could hold the key to retain females (and also males) in advanced mathematics coursework and eventually attract them to the STEM field.

References

- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Psychological Review*, 84, 191-215.
- Betz, M. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior*, 23, 329-345.
- Bishop, J. (1996). Singling the competencies of high school students to employers. In L. Resnick & J. Wirt (Eds.), *Linking school and work* (pp. 79-124). San Francisco, CA: Jossey-Bass.
- Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis in behavioral sciences*. Hillsdale, NJ: Erlbaum.
- Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives*. San Francisco: W. H. Freeman.
- Hoogstra, L. A. (2002). *Divergent paths after high school: Transitions to college and work* (Doctoral dissertation, University of Chicago, 2002). Dissertation Abstracts International, 63, 330.
- Kilpatrick, J. R. (1988). *Influences on choice of major: a causal model across gender* (Doctoral dissertation, University of Toledo, 1988). Dissertation Abstracts International, 49, 232.

- Ma, X. (1997). *A national assessment of mathematics participation in the United States: a survival analysis model for describing students' academic careers*. Lewiston, NY: Edwin Mellen.
- Sells, L. W. (1973). High school mathematics as the critical filter in the job market. *Proceedings of the Conference on Minority Graduate Education*. Berkeley: University of California.
- Shernoff, D. J., & Hoogstra, L. (2001). Continuing motivation beyond the high school classroom. *New Directions for Child and Adolescent Development*, 93, 73-87.
- Stinson, D. W. (2004). Mathematics as "gate-keeper:" Three theoretical perspectives that aim toward empowering all children with a key to the gate. *Mathematics Educator*, 14(1), 8-18.
- Vida, M., & Eccles, J. S. (2003, April). *Predicting mathematics-related career aspirations and choices*. Paper presented at the biennial conference of the Society for Research in Child Development. Tampa, FL.
- Wilson, J. W. (1996). *When work disappears*. New York: Alfred A. Knopf.