ASSOCIATION FOR INSTITUTIONAL RESEARCH
Data and Decisions for Higher Education

Back to All Proposals

PROPOSAL DETAILS

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Project Description I

Title:

Entry and Degree Attainment in STEM:

The Intersection of Race/Ethnicity and Gender

Statement of the research problem and national importance:

The recent release of *National Science and Engineering Indicators* (2012) once again highlight the under-representation of women and non-Asian racial minorities in Science, Technology, Engineering and Mathematics (STEM) degree attainment and the labor force. This is troubling on multiple levels. Individually, STEM graduates have better access to lucrative and prestigious occupations, and the lack of representation of these groups contributes to social inequality. Nationwide, full participation of racial/ethnic minorities and women has increasingly become necessary to maintain the U.S.'s position as a global leader in science and technology. As such, the diversity of talent in STEM fields is not only an issue of social justice, but also one which influences the nation's economic and technological competitiveness.

The under-representation of women and racial minorities in STEM is particularly acute now as racial minorities have made significant inroads into postsecondary institutions, and women have obtained bachelor's degrees at a higher rate than men in recent years (Buchmann and DiPrete 2006). However, the increase of access to colleges and universities does not automatically bring about the increase of enrollment in STEM fields. As such, it is an increasingly worthy task for researchers to understand the process leading to the under-representation of women and racial minorities in STEM fields.

Recent research has injected additional complexity to the theme of under-representation. Women are not uniformly and universally under-represented across STEM subfields. Some fields, notably life sciences, have much wider appeal to women than other fields, such as physics and engineering (England and Su 2006; Frehill 1997; Ma 2009). With regards to racial minorities, research shows that they are as likely as their white counterparts to claim college majors in STEM fields (Hanson 2009; Ma 2009; Riegle-Crumb and King 2010). That is, racial minorities are initially not under-represented in STEM fields; however, it is not clear how or why they are eventually under-represented in STEM degree attainments. Racial disparity in degree attainments generally exists, but we are not sure whether STEM degree attainments pose additional barriers for racial minorities. Research is needed to disentangle the process of STEM degree attainment from the general degree attainment.

In addition, most studies treat gender and racial minorities in the aggregate, as if all men and women share similar experiences in STEM fields. This is also problematic in assuming that gender is irrelevant when we examine racial/ethnic disparities in STEM fields (Muller, Stage and Kinzie 2001). Recent research on subgroups clearly underscores the significance of examining gender and race/ethnicity from an intersectional perspective. Hanson (2006) has found that African American girls, contrary to the expectation that they are doubly disadvantaged in STEM fields as members of two under-represented status groups, show a higher interest and more positive attitude towards science than their white counterparts. Riegle-Crumb and King's 2010 study questions the assumption that "STEM fields are still predominated by white males." However, their study only examines college major choices two years after high school. Their conclusion, as such, cannot apply to ultimate degree attainment, where racial minorities fall behind still.

As such, this study will focus on both the entry and the bachelor's degree attainment in STEM fields—the admission ticket to many STEM occupations (Xie and Shauman 2003). This project will examine the patterns of representation in STEM fields for the intersection of gender and racial/ethnic groups, both at the starting and end points before students obtained their bachelor's degrees. In addition, this project will investigate the factors that contribute to under-representation, and disentangle the process of bachelor's degree attainment from STEM degree attainment. Previous studies consistently show that pre-college factors—including students' attitudes and academic preparations—are most relevant to understanding achievement and choice in STEM fields. The research is less clear regarding the relative importance of these factors. Additionally, this study proposes that external responsibilities arising from family and paid work during school years are also relevant in STEM degree attainments.

The proposed study will use two data sets to investigate these questions: the National Education Longitudinal Studies (NELS) (1988:2000) and the Education Longitudinal Studies (ELS) (2002:2006) from the National Center for Education Statistics. These two datasets, generated almost a decade apart, can provide valuable information regarding potential trends of group equity or inequity in terms of access to STEM fields. The NELS data will also allow examination of the process from entry to degree completion.

Review the literature and establish a theoretical grounding for the research:

Pipeline Model, Cumulative Disadvantage, and Revolving Door?

The "pipeline model" has been widely used to understand the process of choice and attainment in STEM (Berryman 1983; Xie and Shauman 2003). As the imagery of "pipeline" indicates, the process is characterized by the uni-directional rigid steps of choosing a college major and then persisting in the attainment of the degree. Other educational trajectories, e.g., choosing a non-STEM major initially, is viewed as "leaking from the pipeline." The pipeline imagery is grounded in the framework of cumulative disadvantage theory (Merton 1968; DiPrete and Gregory 2006) that posits higher attrition rates among the traditionally under-represented groups, such as women and racial minorities. The theory then posits that the probability of the influx later into the pipeline is small, and therefore, complete persistence should be the dominant path for any group to attain degrees in STEM fields.

Contrary to cumulative disadvantage theory and the pipeline model, the revolving door theory— proposed by Jerry Jacobs in his seminal work (Jacobs 1989) to study occupational sex segregation—provides a different approach that enables a more dynamic and fluid perspective. Jacobs found substantial flows of women into and out of male-dominated occupations. The "revolving door" perspective captures the fluidity in aspirations and choices and allows for delayed entry and attainment. Recent studies provide some empirical evidence to this view (Xie and Shauman 2003; Ma 2011). They find that most female STEM baccalaureates enter the STEM education trajectory during college, after initially expecting a non-STEM college major in high school, whereas most male STEM baccalaureates expected a STEM college major and persisted in college. Ma (2011) further argued that the social control that prevents women from entering math and science fields during pre-college years may ease up in college, which may help account for the influx of women into STEM later in college. However, we are not yet certain of the more complex picture to be gained after examining the intersection of gender and race/ethnic groups.

Academic Preparations, Attitudes and External Responsibilities

Academic preparations and attitudes in pre-college math and science have been identified as the key determinants for participation in STEM fields in college (Adelman 1998, 2006; Smyth and McArdle 2004; Tai, Liu, Maltese, and Fan 2006). Yet, recent research has consistently documented that aggregate gender differences in academic preparations, such as course taking and test scores, are negligibly small and could account for virtually none of the differences in the choice of a STEM major (Simon and Farkas 2008; Xie and Shauman 2003). Fewer studies at the national level examine racial and ethnic disparity, and even less research exists concerning the intersection of gender and race/ethnic patterns. However, some studies have shown that African American females have higher levels of academic preparations than their male counterparts, including test scores and course taking (Hyde and Linn 2006; Riegle-Crumb 2006). It may be that racial minority male students contribute more to the racial disparity in STEM degree attainments than their female counterparts. Academic preparations, in particular, may account for more of the racial disparity in STEM degree attainments for males than for females. This project will take a close look at the above hypotheses.

With regards to student attitudes as determinants for entry and attainment in STEM fields, previous studies have consistently reported evidence to show that students perceive math and science to be male domains (Correll 2001; Eccles 1994). However, in one recent study, Riegle-Crumb and King (2010) investigated attitudes towards math and found that attitudes play the least important role, as compared to academic preparations, in choosing a college major in STEM. The proposed study, however, intends to extend the investigation beyond attitudes towards academic subjects. Attitudes towards money and towards caring and helping other people are key elements of career values (Beutel and Marini 1995; Eccles 1994), which figure as important roles in student decision-making in entering and attaining STEM degrees. Women are shown, in general, to value caring and helping other people more than men and men are shown to value money and prestige more than women. STEM fields are among the most financially rewarding fields, yet pervasive stereotypes exist among young people in the U.S. that scientists and engineers are socially inept, and that work in STEM fields is sedentary and involves little contact with other people (May and Chubin 2003; COSEPUP 2005). This may have some negative impact on women’s inclinations towards STEM fields.

In addition to academic preparations and attitudes, students’ external responsibilities that mainly arise from paid employment may also matter for their choice and attainment in STEM fields. Studies on the relationship between paid employment of high school and college students and academic performance have generated mixed findings. Some researchers found the relationship to be negative and argued that this hampers students’ ability and energy to focus on their studies (Carr, Wright, and Brody 1996; Chaplin and Hannaway 1996). Anderson and Kim (2006) have highlighted that working for more than 14 hours per week has prevented racial minority students from concentrating on their studies, many of whom were unable to keep attending school on a full-time basis. On the other hand, other studies have argued that students brought positive attributes from their external responsibilities to their schooling, and thus, potentially could boost their academic performances (Furr and Elling 2000; Hammes and Haller 1983). This study considers the special characteristics of STEM fields as instrumental to the relationship between the external responsibilities and academic outcomes. STEM subjects often have a more linear and rigid curriculum structure than other subjects, such as history or sociology (Kuhn 1996; Biglan 1983). Students missing one class or a key concept may find it much harder to catch up, and the cumulative effect might debilitate them from moving forward. In other words, the external responsibilities students have to shoulder may more likely negatively impact their academic outcomes in STEM fields than in other fields. Minorities are often vulnerable to external responsibilities (Anderson and Kim 2006), which may help account for their ultimate under-representation in STEM degree attainments.

Describe the research method that will be used:

Research Questions and Analytic Samples

This study intends to investigate the following questions:

- What are the patterns of representation in STEM fields in college for the intersection of gender and racial/ethnic groups? How do these patterns vary by STEM subfields?
- How does the group representation vary at the starting and end points of students' college careers? Is under-representation among minorities driven mainly by their lower overall likelihood of finishing college, or does persisting in STEM fields pose additional barriers?
- What factors contribute to the under-representation of minorities in STEM fields, and what is the relative importance of these factors?

Since this study will examine two sequential outcomes: first major choice and STEM degree attainment, there are two distinct samples. For the first major choice, the sample consists of those who enroll in postsecondary institutions. The estimated number in NELS data is about 9,400, and the estimated number in ELS data is about 10,024. For the STEM degree attainment, the sample consists of all the bachelor's degree earners. In NELS data, about 4,036 students graduated with bachelor's degrees by the year 2000, among whom 1,017 students attained their degrees in STEM fields.

The process of STEM degree attainment is conceptualized as the combination of two nested educational achievements: the attainment of a bachelor's degree and among those students who earn a baccalaureate, the attainment of a STEM degree. The separation of these processes is necessary because it is not clear whether the STEM degree attainment presents a bigger hurdle than degree attainment in other fields. In addition, certain variables such as attitudes and values may figure different roles in bachelor's degree attainments and STEM degree attainments.

Variables

Dependent Variables

The dependent variables are first college majors, bachelor's degree attainments and bachelor's degree majors. Both NELS and ELS data have the first college major information, and bachelor degree major information is obtained from the NELS: 88/2000 Postsecondary Transcript files. The aggregated variable with 12 categories (BAMJR) will be used, and will be further grouped into four major categories: life science; math, physical and computer science; engineering (of all sorts); and non-STEM fields. This coding is a modified version used by the National Science Foundation, as well as other researchers (e.g., Ethington and Wolfle, 1988; Frehill, 1997; Ma, 2011).

Independent Variables

<u>Academic Preparations</u>

Academic preparations include high school course taking and standardized test scores in math and science from the 12^{th} grade. These factors are domain-specific, and considered to be important factors for the bachelor's degree attainment in STEM fields. Course taking information includes highest math in high school and highest science in high school, from both NELS and ELS. Highest math in high school is derived from high school transcripts, and has 9 categories: Basic/Remedial Math, General/Applied Math, Pre-algebra, Algebra I, Geometry, Algebra II, Advanced Math (Algebra III, Finite Math, Statistics), Pre-calculus (includes Trigonometry), and Calculus. Highest science course has 6 categories: Basic or Remedial Science, Earth Science, Biology, Chemistry, Advanced Science (including Biology 2 and Chemistry 2), and Physics.

In addition, academic preparations also include factors that are not domain specific, to predict the model of bachelor's degree attainment. These factors include college first year GPA, students' SAT scores, and high school class rank.

<u>Attitudes/Values</u>

Attitude variables include self-assessment of one's abilities in math and science. Value variables include one indicating whether having lots of money is very important, which was measured during the students' 12th-grade year; the other variable indicates whether helping others in the community is very important. These variables will be used for the models on entry and degree attainment in STEM fields. For the general bachelor's degree attainments, the education expectation variable indicating how far students expect to go in schooling will be used.

<u>External Responsibilities</u>

The proposed study conceptualizes external responsibilities mainly arising from paid work during the school year. For paid work, measures of hours of work per week are included from both the NELS and ELS data. In addition, we also include a dummy variable indicating whether respondents have children. External responsibilities are relevant factors in both bachelor's degree attainments, and STEM degree attainments.

Demographic variables

Demographic variables include gender, race and family socioeconomic status (SES). Race has four categories: non-Hispanic Whites, non-Hispanic Blacks, Hispanics and Asian/Pacific Islanders. Family SES is a composite measure drawing from information of both parents' education, occupation and income.

Control variables

School-level information, including both demographic compositional information, and curriculum information (school course offering, for example) of students' high schools, will serve as control variables.

Statistical models

Given the fact that students who are enrolled in postsecondary institutions are the selected population, the nonrandom nature of the college attendance may confound the process of college major choice. This study will utilize the instrumental variable approach (Heckman, 1995), a similar strategy successfully implemented in previous studies on entry into STEM fields (Ma, 2009; 2011). The variable "education expectation of whether to go to college or not" during 12th grade has been chosen as the instrumental variable for college attendance, because education expectation regarding college attendance is clearly associated with college enrollment, but is not directly linked with college major choice. Please see the attachment for the model specification.

Statistical models for bachelor's degree attainments in STEM fields have two steps. The first step is to model bachelor's degree attainment, and the second step is to model degree attainment in STEM fields among those baccalaureates. Since both the two outcomes have binary categories, logistic n models are estimated. Demographic and control variables will be used to model both the processes of bachelor's degree attainment and STEM degree attainment. As detailed in the variable section, certain factors in academic preparation and attitudes that are math/science domain-specific will be used to predict the process of STEM degree attainment, and other factors that are not particularly attached to math/science will be used to model the process of bachelor's degree attainments in any field. Notably, external responsibilities will be used to model both processes, but they are likely to matter to differing extent.

Uploaded Appendix Document(s):

- statistical model specifications

Project Description II

Will you use NCES target dataset? Yes

Please check all NCES datasets that apply
- Educational Longitudinal Study of 2002 (ELS: 2002)
- National Education Longitudinal Study of 1988 (NELS:88)

Explain why each dataset best serves this research. Include a variable list for each dataset used.

Similar to previous datasets collected by NCES, NELS and ELS data contain rich information on student pre-college academic preparation, including detailed information on coursework, and its postsecondary transcript data contains detailed curriculum and postsecondary attendance and attainment information. The studies also oversampled Asians and Hispanics, which makes it possible to study racial patterns as well. The two datasets are almost a decade apart, providing the opportunity to examine the trend of racial minorities' participation in STEM fields from the 1990s to the first decade of the 21st century. This study will analyze the degree attainment information using NELS data.

A list of Variables

Dependent Variables

First college majors: PSEFIRMJ (NELS), F2B22 (ELS)

Bachelor's degree college majors: BAMJR (NELS)

Bachelor's degree attainment: DEG4 (NELS)

Independent Variables

Demographic variables

Gender: F2SEX (NELS), F1SEX (ELS)

Race: F2RACE(NELS), F1RACE2(ELS)

Family SES: F2SES1 (NELS), F1SES1R (ELS)

Academic Preparations

Highest math course: HIGHMATH(NELS), F1HIMATH(ELS)

Math standardized test score: F22XMSTD (NELS), F1TXMSTD(ELS)

Science standardized test score: F22XSSTD(NELS), NO SUCH VARIABLE IN ELS

Attitudes/Values

Math confidence: F2S22C (NELS), BYS89* (ELS) F1S18* (ELS)

Importance of money: F2D36C (NELS); F1S40C(ELS)

Importance of helping people in the community: F2D36F (NELS); F1S40F (ELS)

External Responsibilities

Marital status: F3MARST (NELS); F2D01 (ELS)

Number of children: F3NUMCHLC (NELS); F2D04(ELS)

Number of hours working per week while in school: JOBLASHR (NELS); F2C31R(ELS)

Weight variables

I will use the weight F2F2P1WT variable from NELS, and the weight variable F2QTSCWT from ELS.

Will you use NSF target dataset? No

Explain why each dataset best serves this research. Include a variable list for each dataset used.

Will you address the NPEC focus topic? No

If yes, please briefly describe:

Project Description III

Provide a timeline of key project activities:

A large part of datawork for the NELS is already done. The rest of the datawork mainly involves the ELS and harmonize the two datasets.

2013 May-August: get the data ready and harmonize the two datasets, get some preliminary analysis done and submit to the Population Association of America Conference (an extended abstract is needed typically in Sep)

2013 fall: data analysis and literature review for the first paper on entry into STEM fields

2014 winter vacation: draft the first paper on entry into STEM fields, to be submitted to the American Sociological Association 2014 conference (deadline mid-late Jan)

2014 spring: data analysis and literature review for the second paper on degree attainment in STEM fields

2014 May: draft the second paper on degree attainment in STEM fields, to present on the AIR Forum.

List deliverables such as research reports, books, and presentations that will be developed from this research initiative:

The plan is to publish two to three articles in top peer-reviewed journals. Conference feedback will be used to revise and submit articles for peer-reviewed journal publications. I will submit and present on American Sociological Association Section on Sociology of Education, Population Association of America, in addition to the mandatory presentation in the AIR forum.

The potential journals I plan to submit to are: *Sociology of Education, Review of Higher Education, and American Educational Research Journal*

Describe how you will disseminate the results of this research:

The results of this study will be shared through research articles, which will initially be submitted to conferences. I will first present locally, in various campus venues, including Center for Policy Research, and Department of Sociology, for which I am affiliated. I was collaborating with the Dean of Engineering School in previous projects, so I am ready to disseminate my findings for this research with the Dean and other stakeholders on campus as well.

I will also present to the national conferences, including American Sociological Association Section on Sociology of Education, Population Association of America, in addition to the mandatory presentation in the AIR forum.

Provide a reference list of sources cited:

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IRB Statement

Statement of Institutional Review Board approval or exemption:

It was determined that the study as submitted does not meet the definition of human subjects' research, and does not require IRB oversight.

Statement of Use of Restricted Datasets

I will use the restricted high school and postsecondary transcript data from both the NELS and ELS surveys. Key course taking information and college major information are from the transcript data.

Biographical Sketch

Yingyi Ma's Biography Sketch

Yingyi Ma is currently an Assistant Professor in Sociology of Maxwell School of Citizenship and Public Affairs at Syracuse University. She is also the affiliated faculty member with Women's Study Department and the program of Asia/Asian American. She obtained her PhD in Sociology at Johns Hopkins University in 2007. Her work deals with a variety of themes of social inequality related to education, gender and migration. Her previous work has been awarded grant from the **National Science Foundation** and **Alfred Sloan Foundation**. She has published more than 10 research articles in peer-reviewed publications. Her recent sole-authored paper in *Social Science Quarterly* (2011), titled "Gender Differences in the Paths of Leading to a STEM Baccalaureate," finds that women are more likely to switch into the STEM fields later in college to attain their STEM bachelor's degrees, and attitudes and course taking behaviors during high school years contribute to the different pathways that men and women travel. While most of her publications are in the U.S context, she has done research in China, centered on the transformative changes in contemporary Chinese society. She recently has done research on Chinese higher education college admission. Her long-term plan is to conduct comparative empirical studies and contribute to the scholarship in globalization, comparative education and stratification.

Budget Requirements

Yingyi Ma' Budget

Personnel-Time on Project
%(FTE) Academic Year: 0.00
%(FTE) Summer: 70.00

Personnel-Salary & Benefits
Academic Year: $ 0.00
Summer: $ 35168.00

Graduate Research Assistant's Budget

Personnel-Time on Project
%(FTE) Academic Year: 30.00
%(FTE) Summer: 90.00

Personnel-Salary & Benefits
Academic Year: $ 20895.00
Summer: $ 6700.00

Total Salary and Wages: $36916.10

Travel: $1000.00
Other travel related expenses: $2000.00
Other research expenses: $60.00
Total Request: $39976.10

Funding History

There is no prior,current or pending funding for the proposed research. The PI has not received any prior funding from AIR.

Statistical model specifications

On college major choice:

Let p represent the probability of college attendance, and X represent a vector of independent variables and control variables, including the instrumental variable. The probit model for college attendance is

$$probit(p) = \alpha + \beta X$$

From probit model, the hazard rate is estimated, representing the probability of not attending college. The variable “hazard” is included in the model of college major choice, to take into account of the selective nature of college attendance.

Given college major choices have 4 categories, I use multinomial logit model for estimation. Let P_j represent the probability of choosing jth college major, j=1, 2, 3 (referring to life science, math/physical science and engineering respectively). The base category is the 4th category, which is the non-STEM field.

$$Log(\frac{P_j}{p_4}) = \alpha + \beta_j X + \delta_j hazard$$

On bachelor’s degree attainments in STEM fields

Let p represent the probability of graduating from college with a bachelor’s degree, X represent a vector of independent variables and control variables to predict bachelor’s degree attainments. Given the dependent variable is binary, logistic regression will be used:

$$\log it(\frac{p}{1-p}) = \alpha + \beta X$$

The second step is to model bachelor’s degree attainment in STEM fields. In a similar vein, let p represent the probability of attaining a STEM bachelor’s degree, X represent a vector of independent variables and control variables for bachelor’s degree attainments, plus Y, a vector of those variables that are domain-specific to math and science. Logistic regression will be used:

$$\log it(\frac{p}{1-p}) = \alpha + \beta X + \phi Y$$