Modeling Entrance Into STEM Fields of Study Among Students Beginning at Community Colleges and Four-Year Institutions

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Background

- The educational pipeline of science, technology, engineering, and mathematics (STEM) fields has been a key preoccupation for researchers and policy-makers.
- The supply side of the STEM pipeline still experiences a deficit.
- Much of the effort in broadening STEM participation will rely on not only four-year institutions, but also community colleges.
- **This study examines factors shaping the decision to pursue STEM fields of study among students entering community colleges and four-year institutions.**

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Theoretical Framework and Literature

- **Social Cognitive Career Theory (SCCT)** (Lent, Brown, & Hackett, 1994)
- Self-efficacy is a central social cognitive construct in SCCT and is theorized to strongly influence one's career interest (Porter & Umbach, 2006; Schunk & Miller,2002).
- Academic experience and preparation in math and science during high school are the cornerstone of their later interest and enrollment in STEM fields (Lent, Brown, & Hackett, 2000; Staniec, 2004).

Theoretical Framework and Literature

- **Postsecondary influences**
  - Academic integration into college (Astin, 1993; Chang, 2005; Lamport, 1993; Terenzini, Pascarella, & Blimling, 1999)
  - Perceived academic readiness for college (Millar, 2010; Rosenbaum, 2001)
  - Taking remedial courses (Adelman, 2006; Attewell, Lavin, Domina, & Levey, 2006; Bahr, 2008; Bailey & Alfonso, 2005; Long, 2005; Pascarella & Terenzini, 2005)
  - Receiving financial aid (DesJardins, Ahlburg, & McCall, 2006; Ishitani & DesJardins, 2002)
  - Having external demands (Bryant, 2001; Kane & Rouse, 1999).
- **Person inputs:** Gender, ethnicity, and socioeconomic status (SES)

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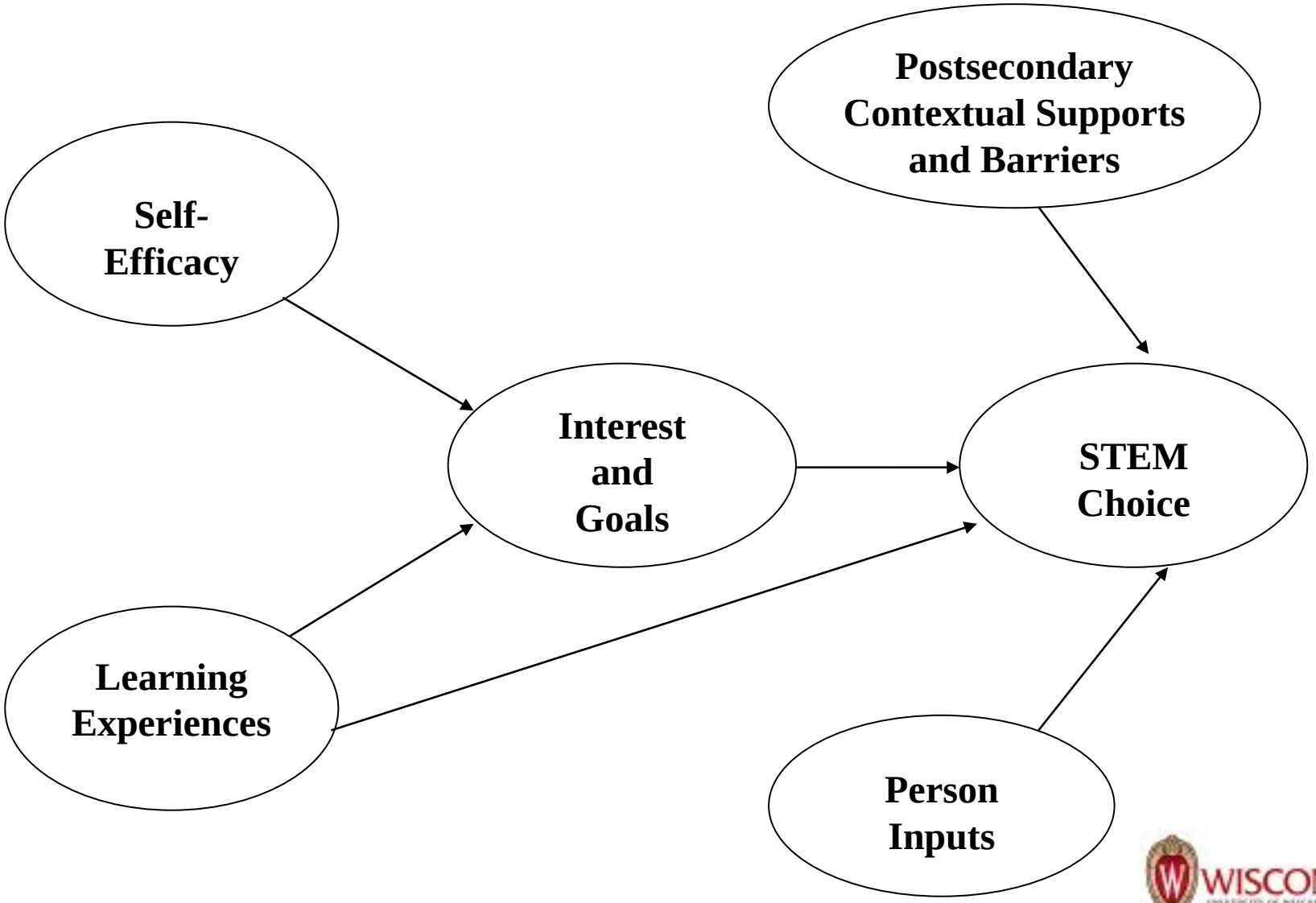
Theoretical Framework and Literature



Method: Data and Sample

- Education Longitudinal Study of 2002 (ELS: 2002), a national, longitudinal survey designed to study high school students' transition from secondary into postsecondary education.
- The baseline survey of ELS:2002 was completed in 2002, when the participants were high school sophomores. The first follow-up survey was conducted in 2004, when most participants were high school seniors. The second follow-up survey was completed in 2006, effectively two years after high school graduation for most survey participants.
- Sample includes students who participated in both the first and second follow-up interviews of ELS:2002 and who had enrolled in a community college (about 6,300; 65%) or four-year institution (about 3,370; 35%).

Method: Measures

Dependent Variable	
STEM choice	Respondent's 2006 major field of study is in STEM.
Mediating Variable	Respondent's most likely field of study upon entering college is in STEM.
STEM interest	
Independent Variable	Can do excellent job on math tests
Math self-efficacy	Can understand difficult math texts
	Can understand difficult math class
	Can do excellent job on math assignments
	Can master math class skills
High school exposure to math and science courses	Units in high school math
	Units in high school science
High school math preparation	High school math standardized score

Academic integration in college	Latent variable measured by: Talk with faculty about academic matters outside of class Meet with advisor about academic plans Work on coursework at school library Use the web to access school library for coursework
Math and science readiness for college	High school math prepared for college High school science prepared for college
External demands	Whether has biological children Whether is married Weekly work hours
Receiving financial aid	Offered financial aid 1st year at college
Number of Remedial Subjects	Number of remedial subjects: reading, writing, and math
Enrollment intensity	1=full-time, 0=part-time
Expecting a graduate degree	Respondent expected to earn a graduate degree

Method: Analytical Approaches

- Structural equation modeling (SEM)
  - Measurement part of the SEM analysis—a confirmatory factor analysis (CFA) was first conducted to measure the latent variables in the proposed model: (a) math self-efficacy, (b) exposure to math and science courses in high school, (c) academic integration in college, (d) math and science readiness for college, and (e) external demands.
  - SEM analysis
    - A one-sample, full structural equation model was initially fitted to the data.
    - The same model was then fitted to the community college and four-year groups separately.
    - Multi-group SEM analyses (i.e., structural path invariance tests) to examine whether the proposed model and its structural path coefficients are equivalent across both student groups

Limitations

- As an extant dataset, ELS:2002 does not necessarily measure all the variables used in the study the way the researcher would have preferred, e.g., interest and goals, academic integration, two-item latent variables.
- Persistence and eventual completion in STEM majors were not addressed given the time frame of ELS.
- Although sometimes referred to as "causal modeling," SEM still explores correlations instead of causal relationships. Therefore, the findings of this study do not imply causal explanations.

Results: Descriptive Statistics

- 4,490(46%) male and 5,280 (54%) female
- White students accounted for 61% of the analytical sample, Asian Americans accounted for 12%, and the rest 27% were underrepresented minorities.
- Students' SES was classified into four quartiles and its distribution from lowest to highest quartiles were 16%, 20%, 26%, and 38% respectively.
- There were 16% of the students who were interested in choosing a STEM field of study upon entering college and 12% actually chose a STEM discipline.

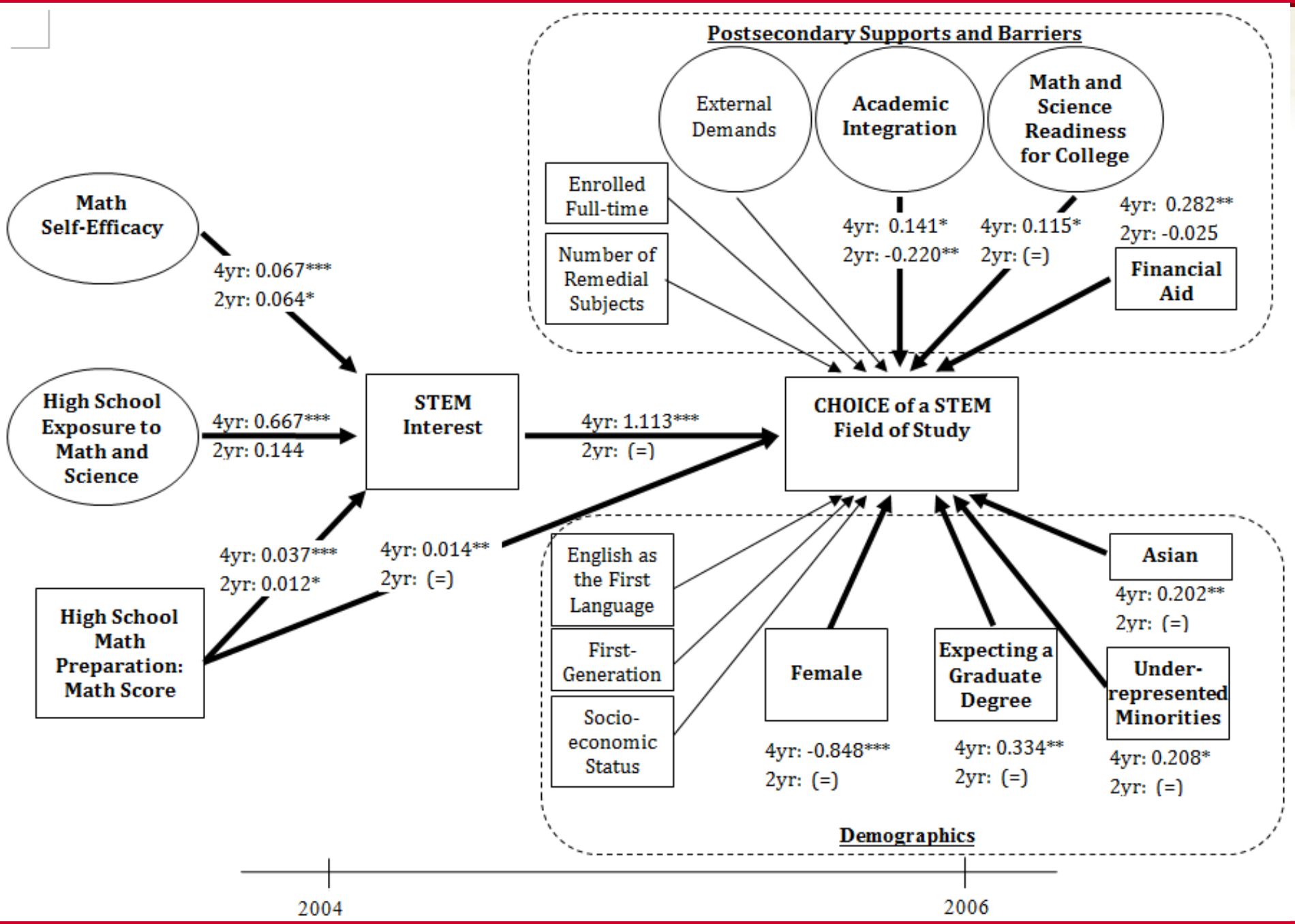
Results of Confirmatory Factor Analysis on the Measurement Model

- The confirmatory factor analysis shows that the proposed measurement model fits the data adequately well
  - $\chi^2(94) = 1{,}666.430$, $p = 0.000$
  - RMSEA = 0.041
  - CFI = 0.986
  - TLI = 0.982

Results: SEM Model Fit Statistics and Results of Structural Path Invariance Tests

Model	χ^2	df	$\Delta\chi^2$ p-value	$\Delta\chi^2$ Test (α=0.05)	RMSEA	CFI	TLI
One sample (N = 9,770)	5615.107	307	--	--	0.042	0.931	0.922
Four-Year Institution Group (N = 6,300)	2765.833	307	--	--	0.036	0.955	0.949
Community College Group (N = 3,470)	1729.023	307	--	--	0.037	0.932	0.922
Baseline multi-group model	4435.937	639	--	--	0.035	0.948	0.943
Individual path coefficient constrained							
Path to STEM Interest							
Math Self-Efficacy	4409.561	640	0.000	Non-Invariant	0.035	0.948	0.943
Exposure to Math and Science Courses	4446.088	640	0.001	Non-Invariant	0.035	0.948	0.943
High School Math Preparation	4441.985	640	0.014	Non-Invariant	0.035	0.948	0.943

Path to STEM Choice							
Interest in a STEM Major	4434.610	640	0.249	Invariant	0.035	0.948	0.943
Academic integration	4440.042	640	0.043	Non-Invariant	0.035	0.948	0.943
Math and Science Readiness for College	4433.967	640	0.160	Invariant	0.035	0.948	0.943
High School Math Preparation	4437.978	640	0.153	Invariant	0.035	0.948	0.943
Receiving financial aid	4445.271	640	0.002	Non-Invariant	0.035	0.948	0.943
External Demands	4435.640	640	0.586	Invariant	0.035	0.948	0.943
Number of Remedial Subjects	4433.287	640	0.104	Invariant	0.035	0.948	0.943
Enrolled Full-time	4434.667	640	0.260	Invariant	0.035	0.948	0.943
Expecting a Graduate Degree	4438.644	640	0.100	Invariant	0.035	0.948	0.943
Female	4438.162	640	0.136	Invariant	0.035	0.948	0.943
Asian	4435.563	640	0.541	Invariant	0.035	0.948	0.943
Underrepresented Minorities	4435.809	640	0.721	Invariant	0.035	0.948	0.943
Socioeconomic Status	4436.053	640	0.733	Invariant	0.035	0.948	0.943
English as the First Language	4434.466	640	0.225	Invariant	0.035	0.948	0.943
First-Generation	4434.685	640	0.263	Invariant	0.035	0.948	0.943
Final model							
13 Invariant Path Coefficients Constrained	4427.826	652	0.836		0.034	0.948	0.944


Postsecondary Supports and Barriers
External Demands
Academic Integration
Math and Science Readiness for College
Enrolled Full-time
Number of Remedial Subjects
4yr: 0.141*
2yr: -0.220**
4yr: 0.115*
2yr: (=)
4yr: 0.282**
2yr: -0.025
Financial Aid
Math Self-Efficacy
4yr: 0.067***
2yr: 0.064*
High School Exposure to Math and Science
4yr: 0.667***
2yr: 0.144
STEM Interest
4yr: 1.113***
2yr: (=)
CHOICE of a STEM Field of Study
4yr: 0.037***
2yr: 0.012*
4yr: 0.014**
2yr: (=)
High School Math Preparation: Math Score
English as the First Language
First-Generation
Socio-economic Status
Female
4yr: -0.848***
2yr: (=)
Expecting a Graduate Degree
4yr: 0.334**
2yr: (=)
Asian
4yr: 0.202**
2yr: (=)
Under-represented Minorities
4yr: 0.208*
2yr: (=)
Demographics
2004
2006

Summary of Results

- All three high school independent variables: (a) math self-efficacy beliefs, (b) exposure to math and science courses, and (c) high school math preparation showed significant positive effects on four-year beginners' interest in choosing a STEM field of study.
- When compared in standardized terms, exposure to math and science and math preparation seemed to have more substantial effects than math self-efficacy beliefs.
- However, these three variables' influences on two-year beginners' interest in STEM were not as substantial as those observed on their counterparts.
  - Exposure to math and science courses was not a significant factor in predicting two-year beginners' interest in STEM.
  - Nonetheless, math self-efficacy beliefs appeared to be the strongest influence on two-year beginners' interest in STEM, followed by math preparation.

Summary of Results

- Students' interest in STEM, math and science readiness for college, and high school math preparation all had significant and positive effects on both two- and four-year beginners' STEM choice.
- Two postsecondary variables exerted differential effects on students beginning at community colleges and those beginning at four-year institutions.
  - Academic integration had a significant and positive effect on four-year beginners' choice of STEM majors, while its effect was significant but negative on two-year beginners' STEM entrance.
  - Receiving financial aid had a significant and positive effect on four-year beginners' STEM entrance; but it reported no effect on two-year beginners' STEM entrance.

Summary of Results

- Of the person input variables, being female were negatively associated with STEM choice.
- Being Asian and being a member of underrepresented minorities were positively associated with choosing STEM areas of study, as compared to being White.
- Additionally, students who expected to earn a graduate degree were more likely to participate in STEM than those who did not.

Discussion and Implications

- High school learning and student motivation as related to math and science have long-term effects on the development of STEM interest that extends to students' postsecondary career leading to actual enrollment in these fields.
- Even with the same amount of exposure to relevant coursework or the same level of math preparation, students who are four-year college bound are more likely to translate high exposure to math and science and high achievement in math into real interest in choosing a STEM fields of study, compared to their counterparts heading to two-year colleges.

Discussion and Implications

- Cultivating STEM interest
  - Given the study's findings, improving math learning, strengthening math self-efficacy beliefs, and introducing students to more math and science offerings
  - These implications may readily apply for the more select, four-year college bound students, but not so much for community college bound students who are largely racial minorities, first-generation college students, and academically disadvantaged (Cohen & Brawer, 2008).

Discussion and Implications

Regarding academic integration—

- Why taking initial interest into account, the "academically integrated" student is more likely to enter STEM in a four-year setting while it is the opposite for a similar student beginning at a community college?
  - Given the status differences between community colleges and four-year institutions, STEM areas in community colleges do not necessarily enjoy the same high prestige as they do in four-year colleges and universities and compared to other program offerings in two-year colleges, may not lead to financially secure and rewarding jobs.
  - Strengthening the collaborations between community colleges' STEM programs and local employers in STEM fields as well to develop seamless upward transfer pathways in STEM

Discussion and Implications

Regarding financial aid—

- For students pursuing a bachelor's degree in a STEM fields, financial aid may help them reduce the need to work and focus on study, which is important given the amount of time and stringent grading system often found in these disciplines (Arum & Roksa, 2011). In this sense, financial aid may facilitate entrance into STEM of those four-year college students who might otherwise find a baccalaureate degree in STEM less feasible to pursue due to time and financial constraints.
- In a community college setting, for reasons discussed previously, choice of STEM may not be a necessary step towards transfer or may not imply immediate opportunities for high status jobs; thus, financial aid may benefit students aspiring to non-STEM fields as much, if not more, as it would for those choosing STEM.

Discussion and Implications

Regarding personal background—

- Gender disparity in participation in STEM pipeline
- Asian Americans and members from underrepresented minorities are more likely to choose STEM, compared to White students.
  - This finding should be considered in conjunction with the much smaller proportion of underrepresented minorities completing STEM degrees. May further underline the high attrition rates of underrepresented minorities from STEM fields (Burke & Mattis, 2007).

Future inquiries and evidence-based policy interventions are needed to further support STEM-aspiring students to enter, persist in, and graduate from these challenging and important fields of postsecondary study.

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Thank You!

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