An Investigation of Factors Related to Student Choice of Academic Major at IUB

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Abstract

Research on academic persistence for university students is well-established, but most often this work is based on secondary analysis of institutional or national datasets. Research on major choice is not nearly as widespread, but most of it also suffers from being based mostly on existing data. The issue with these scenarios is that researchers are limited to what exists and try to answer their own questions in a limited way rather than collecting the best data for the questions of interest. We recently initiated a study to address these limitations. We are working to understand major choice as well as student persistence. We are taking an approach where we plan to learn as much as we can from secondary analysis of a large corpus of longitudinal data as well as conducting our own primary data collection to study student decision-making processes at a much more fine-grained level and in real-time. Our belief is that through applying this multimodal strategy we will be able to analyze key factors with both breadth (across large volume of data) and depth (being able to follow-up with students actively making these decisions). While we are not particularly focused on how to improve student success at the individual class level, we are collecting data at that level to understand more broadly how their experiences and performance play a role in higher level decisions they make about major choice and persistence.

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Background

At the secondary level positive attitudes toward STEM, high achievement, and advanced coursework are associated with choosing a major in STEM (Maple & Stage, 1991; Trusty, 2002; Ware & Lee, 1988).

While Ware et al. (1985) found that student enjoyment in introductory science courses had a positive association with the choice to major in STEM for all students, they reported differences in other factors based on gender. For the female students, high paternal education level, very high Scholastic Aptitude Test (SAT) mathematics scores, and strong desire for control, prestige, and influence were positively associated with selecting a STEM major. For men, precollege science major intentions and high grades in freshman science were positively associated with a major declaration in STEM, whereas paternal education level had a negative relationship. Interestingly, women and men in the sample reported nearly identical educational experiences, but only 31% of the women reported that science was their most enjoyable class (49% of the men reported this). Using data from NELS:88 and from HS&B:82 to investigate student selection of STEM majors, Federman (2007) reported that early mathematics and science achievement, advanced course enrollment, and students' reports of science being useful in their future were all associated with an increase in the likelihood of students' completing a college degree in a STEM field.

This work, in addition to our prior work is almost universally based on secondary analyses of data where researchers are limited to the data that exist rather than thinking about what data will actually answer key questions. We are trying to take both approaches in our ongoing study – using large volumes of extant data to understand larger patterns in addition to a smaller set of data that can shed light on the intricacies of these decisions students are making.

Current Study

The study described here goes beyond looking at data from single courses or programs. The overarching goal of the study is to understand the myriad factors related to student selection of academic majors, with particular emphasis on understanding the flow of students into and out of science, technology, engineering/informatics, and mathematics (STIM/STEM) fields. The current study has two parts: A) analysis of institutional records for IUB alumni and B) a study of 1st year students who entered IUB in summer/fall of 2014 and will be tracked through their first few years at IUB. While this research relates to various elements of the undergraduate experience that are addressed in the IUB Campus Strategic Plan, the most direct is *Objective 5*, related directly to improving STIM education on campus. Because of the longitudinal aspects, this analysis will also contribute to understanding factors related to retention and degree completion.

For Part A, the plan involves investigating extant records of IUB alumni in an attempt to associate student coursetaking and performance with movement into and out of academic majors, with particular focus on those related to STEM. The idea is to see if there are recognizable patterns across an enormous corpus of data in areas of enrollment, completion or performance

that might be associated with student persistence in various majors. For Part B, the main focus is on understanding major selection at a more fine-grained level than has been researched in the past. This means collecting more data, more frequently over an extended period of time. We are currently accomplishing this through short surveys (3-5 items) that go out to participants 1-2 times per week. In addition to these regular surveys we collected background data before students arrived on campus, and plan to conduct a larger collection between semesters and at the end of the academic year. The focus of all surveys is factors related to students' experiences at IUB and involve academic factors (course enrollment, workload), attitudinal measures (feelings of engagement, satisfaction), health (sleep, food intake), participation (club membership, attendance at IU functions), and the persistence of major and career plans. Survey items are asked in a cyclical pattern so that we get repeated measures on many factors over time. Additionally, we plan to supplement primary data with information from student records and institutionally available data on student participation and performance. Finally, we have also conducted interviews with a subset of students who are already indicating plans to change their majors. In sum, there are multiple forms of data collected over various times to understand this phenomenon.

Sample

For Part A, we are using existing institutional data to conduct analysis. These data were obtained from the IU Bloomington Assessment and Research Office and include the academic records of current and former students going back to 1998, based on our established inclusion criteria. These data include academic preparation for university, performance in courses, sequence of courses completed, measures of progression through their degree program, demographics, measures of engagement and credentials earned. In certain cases students may have completed institutional surveys that are tied to their records, and where relevant data are included (e.g., major intention) we hope to include those data in the analysis.

The sample for Part B of the study includes incoming first-years at IUB. A sample of incoming first-year students was randomly selected from all students set to enter IUB in Fall 2014. The population of incoming first-years was split into groups to achieve balance based on their indication of pre-matriculation major preference or direct-admit status, by their racial majority/minority and international status, and by sex. After stratification, 10 sets of ~150 students were randomly selected by the Office of Enrollment Management. Students from the group were solicited to participate in the study via letter/email. After soliciting approximately 1000 students, we had ~160 students agree to participate, although that number has steadily declined over the semester.

For this cohort of students, primary data collection involves taking part in 1-2 short weekly surveys (3-5 questions; 2-3 min) with a few longer (10-15 min) surveys at the beginning/end of the semesters. This will sum to three longer surveys (before school, after fall semester, after spring semester; ~30 short surveys during the weeks of the semester. In cases where we collect evidence that a student changed majors, we are conduct follow-up interview to investigate reasoning. The interviews will focus on what factors led to the decision to change majors. Similarly, if we discover that students are considering leaving IUB for some reason, we plan to follow up with interviews. These interviews are being recorded to allow for later qualitative analysis. Additionally, we will be connecting the in-situ survey data to students' high school and

IUB academic records (as described for Part A of the study) to broaden the scope of analyses available.

Goals

1) Collect a set of pilot data that demonstrates the feasibility of this method of data collection
2) Collect sufficient data to provide initial indication of the relationship between various factors and major selection and persistence. As part of this, we are hoping to find or develop algorithms or tools that will allow us to visualize the flow of students into and out of majors and yield key insights.
3) If there are promising results for Goals 1 and 2, we plan to use results as the foundation for proposals to external funding agencies that will involve expansion of the study within and beyond IUB
4) Consider possible interventions based on findings

Potential Impact

The overarching goal of the study is to understand the myriad factors related to student selection of academic majors. We are already finding evidence for what these factors are. Based on survey data and interviews, students are indicating that their experiences in introductory courses – both good and bad – are influencing their choices. We are also hearing quite a bit about how academic advisors are playing a role in students' decisions. This has come up repeatedly and has been a bit surprising. One area we may follow-up with is how well informed the advisors are about the recommendations they're making as we hear some are recommending the students follow their interests while others are making recommendations based on minimizing academic challenges. What we believe to be unique about this study is the nature of the sample and the holistic nature of data collection. As we proceed during this pilot phase, we hope to learn where to focus more of our attention before expanding the study at IU and into other institutions. We are in the basic learning phase at this point, but plan to be able to move into developing and evaluating interventions as the project progresses.

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EDUCATION

UNIVERSITY OF VIRGINIA — Charlottesville, VA
Ph.D. in Science Education — May 2008

Dissertation Title: Persistence in Science, Technology, Engineering & Mathematics (STEM): An Investigation of the Relationship between High School Experiences in Science and Mathematics and College Degree Completion in STEM Fields

UNIVERSITY OF CONNECTICUT — Storrs, CT
M.S. in Geology — May 2003

HAMILTON COLLEGE — Clinton, NY
B.A. in Geology, Minor in Anthropology — May 1997

EMPLOYMENT EXPERIENCE

INDIANA UNIVERSITY — Bloomington, IN
Associate Professor of Science Education — July 2014-Present
Adjunct Faculty in Geological Sciences

Teaching Experience

- Exploring Secondary Science Teaching (Undergraduate/Graduate)
- Demonstration and Field Strategies in Science (online; Graduate)
- University Science Teaching (Doctoral Seminar)
- Science Education Curriculum (Doctoral Seminar)
- Our Habitable Planet (Lab Instructor; Undergraduate – Geological Sciences)
- Introduction to Environmental Field Methods (*planned*; Undergraduate – Geological Sciences)

Assistant Professor of Science Education — 2008-2014

PUBLICATIONS

JOURNAL PUBLICATIONS *(PEER REVIEWED)*

[**R** USED TO DESIGNATE PAPERS AS RESEARCH, **T** AS TEACHING, *STUDENT CO-AUTHORS*]

18) **Maltese, A. V.**, *Harsh, J.*, & Svetina, D. (In Press). Interpretation of graphical representations along the novice – expert continuum. *Journal of College Science Teaching*. **[R]**

17) Balliet, R., Riggs, E. M. & **Maltese, A. V.** (In Press). Students' problem solving approaches for developing geologic models in the field. *Journal of Research in Science Teaching*. **[R]**

16) **Maltese, A. V.**, *Melki, C. S.*, & *Wiebke, H.* (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education, 98*(6), 937–962. **[R]**

15) **Maltese, A. V.**, Ross, H. A., *Wang, L.* & *Wang, Y.* (2014). Assessing Multinational Interest in STEM: Implementing a comparative survey research study in China. *International Journal of Chinese Education, 3*(2014) 109-131. DOI 10.1163/22125868-12340032 **[R]**

14) *Timme, N., Baird, M., Bennett, J., Fry, J., Garrison, L.*, & **Maltese, A. V.** (2013, May). A Summer Math and Physics Program for High School Students. *The Physics Teacher, 51*(5) 280-285. **[R/T]**

13) **Maltese, A. V.**, *Balliet, R.*, & Riggs, E. M. (2013). Through their eyes: Tracking the gaze of students in a geology field course. *Journal of Geoscience Education, 61*(1) 81-88. **[R]**

12) **Maltese, A. V.**, Tai, R.H., & Fan, X. (2012). When is homework worth the time? Evaluating the association between homework and achievement in high school science and math. *The High School Journal, 96*(1) 52-72. **[R]**

11) *Harsh, J.*, **Maltese, A. V.**, & Tai, R. H. (2012). A perspective of gender differences in chemistry and physics undergraduate research experiences. *Journal of Chemical Education, 89,* 1364-1370. dx.doi.org/10.1021/ed200581m **[R]**

10) **Maltese, A. V.** & Hochbein, C. (2012). The consequences of school improvement: Examination of the association between school improvement and student science achievement. *Journal of Research in Science Teaching, 49*(6) 804-830. **[R]**

9) *Bennett, J., Fry, J. Timme, N.*, & **Maltese, A. V.** (2012, March/April). Lessons learned from a summer preparatory program on foundations in physics and calculus. *Journal of College Science Teaching, 41*(4), 52-56. **[T]**

8) **Maltese, A. V.** & Tai, R.H. (2011). Pipeline Persistence: The effects of school experiences on earning degrees in STEM. *Science Education, 95*(5) 877-907. **[R]**

7) *Harsh, J.*, **Maltese, A. V.**, & Tai, R. H. (2011). Undergraduate Research Experiences from a longitudinal perspective. *Journal of College Science Teaching, 41*(1) 84-91. **[R]**

6) **Maltese, A. V.**, Tai, R. H., & Sadler, P. M. (2010). The effect of high school physics laboratories on performance in introductory college physics. *The Physics Teacher, 48*(5) 333-337. **[R]**

5) **Maltese, A. V.** & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education, 32*(5) 669-685. **[R]**

4) **Maltese, A. V.** (2009, April/May). Shake, rattle and hopefully not fall. *Science and Children, 46*(8), 40-43. **[T]**

3) **Maltese, A. V.**, Dexter, K. M., Tai, R. H., & Sadler, P. M. (2007). Breaking from tradition: Unfulfilled promises of block scheduling in science. *Science Educator, 16*(1), 1-7. **[R]**

2) Tai, R. T., Sadler, P. M., & **Maltese, A. V.** (2007). A study of the association of autonomy and achievement on performance. *Science Educator, 16*(1), 22-28. **[R]**

1) Tai, R. T., Liu, C. Q., **Maltese, A. V.**, & Fan, X. T. (2006, May 26). Planning early for careers in science. *Science, 312* (5777), 1143-1144. **[R]**

Book Chapters (Peer Reviewed)

Maltese, A. V. & *Harsh, J. A.* (In Press). Pathways of entry into STEM across K–16. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), Interest and the Self in K-16 Mathematics and Science Learning. Washington, DC: American Educational Research Association. **[R]**

Maltese, A. V., Potvin, G., Lung, F., & Hochbein, C. (In Press). STEM Education in the United States. In B. Freedman, S. Marginson, & R. Tytler (Eds.), The Age of STEM: Educational policy and practice in Science, Technology, Engineering and Mathematics across the world. London: Routledge**. [R]**

FUNDING

RESEARCH

National Science Foundation — Pending
Studying and improving data visualization literacy using Macroscopes [Co-PI] — $2,231,000

National Science Foundation — Pending
Collaborative Research: Performance-based assessment of undergraduate researchers' scientific thinking skills [Co-PI] — $248,000

Google Faculty Research Awards — Pending
"Making" STEM pathways [PI] — $111,500

National Science Foundation (DUE-1140445) — 2012-2014
US-MORE – research to investigate the variation in experiences and outcomes in undergraduate research in the fields of chemistry and physics. [PI] — $199,500

National Science Foundation (DRL-1223698) — 2012-2014
Informal Science Education Pathways: Sense-Making of Big Data – research to investigate how children and adults interact with visual representations of large data sets within various informal education setting. [Co-PI] — $250,000

S. D. Bechtel Jr. Foundation — 2011-2015
Spark to Flame – research study to investigate student engagement in STEM longitudinally across grades 3 through 12. [Co-PI] — $600,000

Faculty Research Support Program (IU Internal) — 2013
Assessing Multinational Interest in STEM – funding to survey international sample of students regarding the development and maintenance of their interest in STEM. [PI] — $70,000

Maris M. Proffitt and Mary Higgins Proffitt Endowment Grant (IU Internal) — 2012-2013
Funding for research on student entry and persistence in STEM using multiple federal data sets. [PI] — $19,000

U.S. Department of Education — 2010-2012
Chicago Public Schools - Science and Math Engagement Initiative. [Evaluator] — $134,000

National Aeronautics and Space Administration — 2009-2012

Chicago Public Schools - Capstone Course for Space Science. [Evaluator] $107,000

Faculty Research Support Program (IU Internal) 2010-2011
Getting to the CoRe of It! Transforming Preservice Teachers' Learning of Science – funding to investigate impact of synthesis strategies on content learning in geology. [Co-PI] $34,000

Indiana Education Database Grant Program (IU Internal) 2010-2011
Funding for research to investigate the progression of students from high school to college and from college to graduate school in STEM disciplines. [PI] $15,000

Maris M. Proffitt and Mary Higgins Proffitt Endowment Grant (IU Internal) 2009-2011
Funding for research investigating the understanding and creation of graphs and tables used to represent data in the Geosciences. [PI] $38,000

SERVICE

COMMITTEES

Professional

NARST Outstanding Paper Award	2009-2012
Review of Indiana Developmental & Content Standards for Educators	2010
Revision of Indiana's Academic Standards for Science (Earth Science)	2008-2009

School of Education

Secondary Education Council (Chair)	2014-2015
Learning and Teaching with Technology	2012-Present
Faculty Development Committee	2010-Present
Armstrong Teacher Educator Award Selection Panel	2009-2010

REVIEWER

Journal of Research in Science Teaching	2006 - Present
Journal of Chemical Education	2006 - Present
Journal of College Science Teaching	2006 - Present
Science Education	2011 - Present
NSF Grant Review (Panel & Ad Hoc)	2012 - Present
US-Israel Binational Science Foundation Grant Review (Ad Hoc)	2013
Learning and Individual Differences (Ad Hoc)	2009 - Present
Education Sciences (Ad Hoc)	2014
Equality, diversity and inclusion: An international journal (Ad Hoc)	2014
Learning and Instruction (Ad Hoc)	2013
Research in Science & Technological Education (Ad Hoc)	2013
American Educational Research Journal (Ad Hoc)	2012
The Physics Teacher (Ad Hoc)	2010

AFFILIATIONS

American Association for the Advancement of Science
American Educational Research Association
National Association of Geoscience Teachers
National Association of Research in Science Teaching
National Science Teachers Association