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Who succeeds in STEM studies? An analysis of Binghamton University undergraduate students

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ABSTRACT

Using student level data, the characteristics of STEM and Non-STEM students are examined for attributes associated with academic success. We use fixed effects models to analyze the variables' role in attaining graduation and college GPA and find preparation and ability, as evidenced by Advanced Placement course work, mathematical ability, gender, ethnicity, high school GPA and college experience are all statistically significant indicators of success. These attributes may confer a comparative advantage to STEM students. The engineers have statistically significant differing response elasticities than the non-engineers, and show evidence of persistence that may arise from learning-by-doing. A successful engineering STEM major at Binghamton has good mathematics preparation, and disproportionately is of Asian ethnicity. Women are few in numbers as engineers. Other STEM fields see less emphasis on mathematics preparation, but more emphasis on the presence of AP course work. Women have the same presence in these other STEM fields as in the whole university.

1. Introduction

The question of academic success is important for American society and the apparent paucity of STEM students is of national concern. As an example, the number of undergraduate students earning a degree in engineering and engineering technologies has fallen about 16 percent over a twenty-year period (1985–86 to 2005–06). The first fifteen of these years saw a decline of 25%. But, the last five saw the number of degrees conferred in engineering and engineering technologies increase 12%, though the numbers did not reach the level of 1985–86. The decline was uneven when specific fields are considered. For example, Chemical and Civil Engineering had positive growth from 1985–86 to 1995–96. But from 1996–97 to 2001–02 all the engineering fields declined (National Academies, 2006; Snyder & Dillow, 2010; US Department of Education, 2009).

If one looks at the history of people who are successful in the arts such as music or dance, or one considers people who are successful in highly technical fields such as astrophysics, we find these individuals often had an interest in their area since early childhood or at the least, since middle school. So it should be no surprise that the successful students in STEM courses probably had an interest in STEM fields for many years before college. Is this early interest evidence of a comparative advantage? Or does this early experience provide learning-by-doing?

Following that line of thought, researchers have considered STEM precursors in K-12 schools. For example, various international surveys on high school students' science and mathematics performance are conducted (Baldi, Jin, Skemer, Green, & Herget, 2007; Gonzales et al., 2008).

However, less attention has been focused on the problem in higher education and the observed high drop-out

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rates from science and mathematics majors. Women and/or non-white students opt out of STEM majors at disproportionate rates. And US universities have not kept pace with rest of the world in the production of STEM graduates. Even though a young student's interest in a STEM career may start before she enters college or a university, it's the postsecondary education that creates the career path and prepares the student for work in a STEM occupation. Hence, it is important to analyze the university/college experience with STEM courses and the reasons for the high attrition rates from STEM majors.

Our paper examines the characteristics of STEM students at Binghamton University (State University of New York at Binghamton) and explores the differences between STEM students and Non-STEM students in an attempt to shed light on the question of academic success. We also test the validity of some of the hypotheses that have been offered to explain the gap between intended and completed STEM field majors. We must caution the reader that we have not found a clear answer to these questions, but we have found some things that are important including the differential of the correlates of a student's academic success in various STEM and Non-STEM fields.

In the following sections, we first consider some definitional issues, and next discuss STEM research. This is followed by a description of our model for subsequent econometric analysis. The fifth section is a description of Binghamton data and the sixth section gives the results of the econometric analysis. Finally, we discuss and conclude.

2. STEM students and academic success

The National Center for Education Statistics of the US Department of Education (2006) developed a definition of a STEM degree listing degree programs that include science, technology, engineering, or mathematics degrees. The National Science Foundation defines STEM fields more broadly and includes not only the common categories of mathematics, natural sciences, engineering, and computer and information sciences, but also social/behavioral sciences as psychology, economics, sociology, and political science. This classification issue is discussed in Chen and Weko (2009). We applied the first definition, eliminating the social sciences from our study. Using the Binghamton list of majors, we found 18 engineering majors and 34 other non-engineering STEM fields in which degrees were offered.

The definition of success is more difficult; grades, graduation rates, persistence, completion time, or time to degree are often used. Measures such as Grade Point Average (GPA)[2] and time to degree are relatively easy to measure, but persistence is not. A student may 'persist' in their quest for education and a degree at many campuses and schools over the course of many years. This may mitigate the perceived high drop-out rates. And the scientific and engineering communities have need for substantial numbers of support personnel such as lab assistants and technical writers. These may be provided from the ranks of those who formally drop out of STEM studies but are better trained individuals for their academic experience. We are not able to follow such a student or drop-out with our data and thus this issue is not addressed.

A further criticism of graduation or grades as a measure of a successful outcome is that they do not reflect the quality of the education of the student. The time students spend in exploring different majors and taking elective courses may better prepare them to be life-long learners and better citizens. From this perspective, measures of the educational output are the intelligence, the existence of a breadth of knowledge, understanding, their ability to adapt and learn on the job and thus become more productive, and personal satisfaction of the citizenry as well as their contribution to the commonweal.

We use both Grade Point Average and graduation rates as measures of success in this paper. We do note there are limitations to both; Bretz (1989), using Meta analysis, found success in a field is weakly related to GPA for some fields (e.g. teaching) but not related to success in most fields. Further, graduation rates are partially controlled by institutional characteristics, particularly funding. A good introduction to modern research on this issue together with a good bibliography is given in Calcagno, Bailey, Jenkins, Keens, and Leinbach (2008). Also see DesJardins, Kim, and Rzonca (2002–2003) and Braxton and Hirschy (2004, 2005). Many of the issues are identified in Habley and McClanahan (2004). Adelman (1999) is also useful.

Neither the use of grades nor that of graduation, considers variations in the length of a degree program. The idea of a traditional four-year degree program is not universal and this is relevant to STEM studies as many engineering and architectural programs are five years in length. Some other programs, such as three-two programs, where the student spends time in industry or some other field of study such as business, often require five years of study also. Finally, certification in some sub-field, employment, earnings subsequent to graduation, marriage, citizenship, and literacy are some further possible measures of success. There is some evidence that certification or its equivalent is useful in the STEM field of computers or information technology (Chen & Weko, 2009).

3. STEM research

Much of the literature of these metrics is descriptive and/or discusses the relationship among various student and institutional characteristics and the outcome. Baseline studies by Tinto (1975, 1982), Pascarella and Terenzini (1991) and Astin and Astin (1992) omit the role of resources, other than student financial assistance (see Archibald & Feldman, 2008). Others like Kuh (2003) who conducted research into student engagement found most, if not all, of the educational engagement factors studied have significant financial implications for the institution. And work by Kokkelenberg, Blose, and Porter (2006) found that institutional expenditures, adjusted for types of majors, to be most important in helping students achieve timely graduation.

Very few studies analyzing university/college education of STEM use longitudinal data, but two recent, notable

[2] See Cohn, Cohn, Balch, and Bradley (2004).