The Representation of Minority, Female, and Non-Traditional STEM Majors in the Online Environment at Community Colleges: A Nationally Representative Study

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Abstract

Using data from the more than 2,000 community college science, technology, engineering, and mathematics (STEM) majors in the National Postsecondary Student Aid Study, this research investigates how ethnicity, gender, non-traditional student risk factors, academic preparation, socio-economic status, and English-as-second-language/citizenship status relate to online course enrollment patterns. Even after controlling for other factors, Blacks and Hispanics (Black and Hispanic men in particular) were significantly underrepresented in online courses, women were significantly overrepresented, and students with non-traditional student risk factors (delayed enrollment, no high school diploma, part-time enrollment, financially independent, have dependents, single parent status, and working full-time) were significantly more likely to enroll online. However, while ethnicity, gender, and non-traditional factors were all important predictors for both two- and four-year STEM majors, at community colleges, ethnicity and gender were more important predictors of online enrollment than non-traditional characteristics, which is the opposite pattern observed at four-year colleges.

Keywords: Online learning, ethnicity, gender, non-traditional students, enrollment, college access

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At the same time that the United States faces an escalating need for qualified science, technology, engineering, mathematics (STEM) graduates, the relative proportion of students majoring in STEM fields is shrinking (Kuenzi, Matthews & Mangan, 2006; National Research Council, 2007; U.S. Department of Education, 2011). This shortage of STEM degrees is exacerbated by the fact that while the proportion of minority students in the college-going population is steadily increasing, minority and female students do not complete programs in STEM disciplines at the same rates as their White male peers, (Anderson & Kim, 2006; Mooney & Foley, 2011; National Science Board, 2008; U.S. Department of Education, 2011). In addition, about half of all undergraduate students begin their studies at community colleges, where students are less likely to complete STEM degrees, in part because those students who attend community colleges are more likely to come from groups traditionally underrepresented in higher education and to have more disadvantaged backgrounds (Fast Facts, 2012; Mooney & Foley, 2011; Paying Double, 2006; U.S. Department of Education, 2009, 2011).

Concomitant with the rising need for STEM graduates, the proportion of students taking courses online is growing rapidly, far exceeding the growth of U.S. higher education generally (Allen & Seaman, 2010, 2013; National Science Foundation, 2005; Parsad, Lewis & Tice, 2008). This is particularly apparent at community colleges where, since 2010, online enrollment has increased 29% (CCRC, 2013). However, whether online offerings actually increase access and success in college remains unclear (Jaggars, 2011). In particular, potential online enrollment differences by student characteristics, such as gender and ethnicity, have been noted (Conway, Wladis, & Hachey, 2011; Wladis, Hachey, & Conway, 2012). Moreover and specific to STEM, attrition rates seem to be significantly higher for online STEM courses. A recent study found that the gap in attrition between the same courses offered online versus face-to-face was larger for STEM than for non-STEM courses, suggesting that there may be factors in the online environment which impact STEM courses differently or more strongly than courses in other subjects (Wladis, Hachey, & Conway, 2013, 2012). Thus, there is a strong need to identify factors that might impact STEM student enrollment and success in the online environment.

The literature on face-to-face student retention, small-scale studies of general online learning, and our recent research analyzing undergraduates in all majors who take online courses, together provide significant evidence that gender, ethnicity and non-traditional student risk factors can impact college persistence (Adelman, 2006; Aragon & Johnson, 2008; Bean & Metzner, 1985; Dupin-Bryant, 2004; Moore, Bartkovich, Fetzner & Ison, 2004; Morris, Wu & Finnegan, 2005; Muse, 2003). However, because of the distinct features of the community college environment, these previous findings likely cannot be generalized to STEM majors at community colleges without modification—this leaves a gap in our understanding of the demographic factors related to online STEM enrollment. Thus, this study investigates what differences might exist between community college STEM majors who take courses online and those who do not, with a particular aim to determine if all ethnicities, genders and both traditional and non-traditional STEM majors at community colleges are represented proportionally in the online environment.

Throughout this paper, we use the term *non-traditional* to refer to students who fit a specific set of pre-determined characteristics. The most regularly used definition of non-traditional student characteristics is that outlined by the National Center for Education Statistics (NCES) (1996, 2002); a student is classified as non-traditional if he/she possesses one or more of the following characteristics: Delayed enrollment; No high school diploma; Part-time enrollment; Financially independent; Have dependents; Single parent status; Working full-time while enrolled. Non-traditional students are increasingly making up a majority of the college population and are particularly highly represented at community colleges: for the NCES

2008 data used in this study, 52% of students at public four-year versus 88% of students at public two-year institutions had at least one non-traditional student risk factor.

Literature Review

The Need for STEM Enrollments and STEM Graduates in the U.S.

Although half of all U.S. economic growth is attributed to STEM fields and STEM-related job openings are projected to grow exponentially in the next decade, there currently is a severe shortage of qualified U.S. STEM workers (Babco, 2004; Lufkin, 2008; Obama, 2012; National Science Foundation, 2005; Terrell, 2007). For graduates of the class of 2018, there will be more than eight million STEM job openings (Carnevale, Smith, & Strohl, 2010). Recent trends in college enrollments show an increase in STEM, reversing declines seen in prior decades (U.S. Department of Education, 2011). However, disparities exist among population groups, with minorities and women traditionally underrepresented in STEM undergraduate programs and in the STEM workforce (George, Neale, Van Horne & Malcom, 2001; Hagedorn & Purnamasari, 2012). The enrollment mix is changing as Black, Hispanic, and American Indian/Alaska Native students are now choosing STEM fields at the same rate as White students (National Science Board, 2008). However, majoring in STEM does not equate to graduating with a STEM degree; minority students are less likely than their White student peers to persist, resulting in fewer minority students in graduate STEM programs relative to their proportion in the undergraduate college population (11% versus 30%) (Anderson & Kim, 2006; National Science Board, 2008). In a similar vein, despite increased enrollment of women in college, women are less likely to major in STEM and when they do, they are still less likely to work in a STEM field (Hagedorn & Purnamasari, 2012; U.S. Department of Commerce, 2011).

The underrepresentation of minorities and women in STEM degree programs exists at a time when much of the future growth in U.S. college enrollments is projected to come from minority student groups attending community colleges. Minority groups, often underrepresented in STEM fields, are soon to be the majority of school-age students in the United States. From

2000 to 2050, the Asian and Hispanic college-age populations are projected to more than double, while the Black college-age population is projected to rise by 48% (Frey, 2012; National Science Board, 2008). Attracting and retaining minority students to STEM fields is essential to meeting workforce demands.

The Role of the Community College in Educating STEM Majors

Almost half of all bachelor's and master's degree recipients in science, engineering and health attend community college classes at some point (Mooney & Foley, 2011); yet, the pursuit of a STEM degree differs significantly by level of degree. Among degree types, associate's degree programs are faring the worst, with a decline in STEM degrees conferred between 2000-01 and 2008-09 of almost 9% (U.S. Department of Education, 2011). Students who enroll directly in a baccalaureate program at a selective institution, and attend full-time, are more likely to major in STEM disciplines than other students. STEM students are also more likely to come from the highest income quartile, and to have a parent who attended college and/or worked in a STEM field (U.S. Department of Education, 2009). Some of the reasons cited for the failure of students to enroll or persist in STEM degrees include inadequate high school preparation, lack of role models, stereotype threat, implicit bias among faculty and classmates, lower cultural capital, and difficulty of coursework (American Association of State Colleges and Universities, 2005). Certainly, these factors provide a compelling rationale for the lack of STEM success at open enrollment community colleges, where 60% of the students attend part-time, the average age is 28, 45% are first in the family to attend college and 42% of all freshmen need at least one remedial course (Fast Facts, 2012; Paying Double, 2006).

In a six-year longitudinal study (U.S. Department of Education, 2009), students who entered an associate's degree program in a STEM field were far less likely to have attained a degree than their peers who began in a baccalaureate program majoring in STEM. Almost half of all students entering a STEM program at a community college changed majors or dropped out of school six years later. Even more problematic, only 7.3% of students who began at a two-year college received a STEM bachelor's degree after six years, compared to 45% of students who started in a four-year program (U.S. Department of Education, 2009). In addition, older, independent, Black or Hispanic students were less likely to attain a STEM bachelor's degree and were more likely to drop out of college without a credential. The data points to a critical need to improve both the gateway into STEM programs and to provide assistance towards completion, particularly at the community colleges which have high populations of minority and female students.

Online Learning and Community Colleges

With nearly half of all college freshmen beginning at a community college, one means of meeting the increased demand is to offer classes online (Fast Facts, 2012). Viewed as providing a means of universal education, online courses are now a central feature of most colleges and universities (Caswell, Henson, Jensen & Wiley, 2008; Downes, 2005; Larreamendy-Joerns & Leinhardt, 2006; Sutton & Nora, 2008). They are particularly prevalent at community colleges: almost half of all e-learning programs in the U.S. are hosted by community colleges; community colleges have the highest enrollment rates of all higher education institutions offering online courses. Approximately, 97% of all community colleges have online programs and more than 60% of all community college students today are enrolling in online courses (Obama, 2012; Parsad, Lewis & Tice, 2008; Pearson Foundation, 2011; Ruth, Sammons & Poulin, 2007). The data show that online enrollment growth is far outpacing the growth in overall higher education enrollments (Allen & Seaman, 2010).

The rise in online learning across higher education suggests that it will likely have an escalating impact on STEM course and degree completion. Despite this, little data is available on the number of STEM courses offered online, particularly at community colleges. According to the American Association for the Advancement of Science (AAAS), the major reason that little is known about STEM enrollment, retention and graduation at the community college level is because the majority of previous studies have been conducted at Research Extensive and Research Intensive universities, with few looking at community colleges, Historically Black Colleges and Universities, institutions serving concentrations of Hispanic Americans, tribal colleges, women's colleges, or colleges and universities that target or serve persons with disabilities (George, Neale, Van Horne & Malcom, 2001). Compounding the issue, currently no national dataset specifically for online learning exists; researchers who work with national databases on undergraduate education have lamented their incompleteness (Norris, 2002). A recent study of community colleges in Washington State by Xu & Jaggars (2013) found the proportion of online computer sciences enrollments to be 15%, the proportion of online mathematics enrollments to be 6.6% and the proportion of online natural science enrollments to be 8.4% (there was a wide variation noted within the natural sciences –e.g. the proportion for online Astronomy was 33.4%). However, the community colleges that Xu & Jaggars drew from were noted as disproportionately White and with less federal financial aid then national samples, which limits the generalizability of these numbers. A Sloan Foundation study found that the proportion of institutions offering a fully online program in a STEM field ranged from 17% in engineering to 31% and 33% in computer sciences and health professions and related sciences (Allen & Seaman, 2010). The Sloan study captured data only on fully online programs; however, the number of community colleges offering online courses in STEM fields is likely commensurate. For example, at a large, diverse, urban community college in the Northeast, whose student body is likely representative of the 82% of U.S. community colleges located at or on the fringes of large and mid-size cities (U.S. Department of Education, 2003), institutional records indicate that as much as one quarter of the courses offered online each semester are within STEM disciplines.

Student Characteristics as a Factor in Online Enrollment

There is little evidence to support the claim that online courses increase access (Jaggars, 2011), although improved access is often assumed (Allen & Seaman, 2010; Cox, 2005; Epper & Garn, 2003). Some research suggests that online course offerings do not attract new students to college but may aid existing students in attaining a degree (Jaggars & Xu, 2010). The research seems to suggest that students at risk of non-completion of their degree because of work and family commitments show a significantly greater preference for the flexibility and convenience of online courses (Pontes, Hasit, Pontes, Lewis & Siefrig, 2010; Skopek & Schuhmann, 2008). Additionally, some research has shown that online education attracts a larger proportion of first generation students than do traditional university settings (Athabasca University, 2006).
There is tentative evidence that online learners may be more likely to possess non-traditional student characteristics (Rovai, 2002; Pontes, Hasit, Pontes, Lewis, & Siefring, 2010; Wladis, Hachey, & Conway, n.d..)

And in another study using national data, moderately or highly non-traditional students were more likely than either traditional students or minimally non-traditional students to participate in online education (Choy, 2002). Further, there is evidence that non-traditional students are more likely to be non-White and to be female (NCES, 1996; 2002; Wladis, Hachey, & Conway, n.d.); this implies that non-traditional characteristics may serve as a mediating variable for differences in online participation by ethnicity and gender. Non-traditional student characteristics have historically been associated with higher rates of college attrition (Adelman, 2006; Bean & Metzner, 1985; Berkner, He & Cataldi, 2002; Horn, Cataldi, & Sikora, 2005; Rovai, 2002; NCES, 1995, 1996); however, data on the effect of non-traditional characteristics on online enrollment and persistence generally has been incomplete and inconsistent, and for community college STEM majors specifically, non-existent.

Research has found online learners (not STEM specific) are more likely to have the following characteristics: female, older, married and with other responsibilities (Dutton, Dutton

& Perry, 2002; Guri-Rosenblit, 1999; Halsne & Gatta, 2002; Jaggars & Xu, 2010; Moore & Kearsley, 2005; Qureshi, Morton & Antosz, 2002; Xu & Jaggars, 2011); thus they can be identified as non-traditional based on the NCES criteria used in this article. Some studies have also found that online students tend to have higher levels of academic preparation and higher grade point averages, to be White, native English speakers, and more likely to have applied for or received financial aid (Wladis, Conway, & Hachey, n.d.; Jaggars & Xu, 2010; Xu & Jaggars, 2011). Some of these student characteristics are correlated with lower rates of persistence and success in degree attainment (e.g. work and family obligations (Adelman, 2006; Bean & Metzner, 1985) and part-time attendance (King, 2002) and have been cited specifically in studies of online course withdrawal (Ashby, 2004; Yorke, 2004). On the other hand, some of these characteristics are correlated with higher rates of enrollment and success (e.g. female gender (Chee, 2005; Conway, 2009; Freeman, 2004; Voorhees & Zhou, 2000) and higher levels of academic preparation (NCES, 2005). Additionally, part-time attendance has also been suggested as affecting the enrollment and persistence of online students (Aragon & Johnson, 2008; Dupin-Bryant, 2004; Moore, Bartkovich, Fetzner & Ison, 2004; Morris, Wu & Finnegan, 2005; Muse, 2003). In general, much of the research on the impact of demographic variables on enrollment and persistence in the online environment is conflicting (Jones, 2010).

Some student characteristics significant in traditional models of face-to-face enrollment and retention have also been identified for the online student: grade point averages (GPA), Math scholastic aptitude test (SAT) score, class rank, and attending full-time (Aragon & Johnson, 2008; Dupin-Bryant, 2004; Moore, Bartkovich, Fetzner & Ison, 2004; Morris, Wu & Finnegan, 2005; Muse, 2003). However, some of these factors may be less relevant for community college students who are more likely to attend part-time and who attend open admissions institutions that rely on neither class rank nor SAT scores in admissions. Furthermore, little research focuses on issues of academic preparation, socio-economic status (SES), ethnicity, or English language skills among online community college students, either generally or specific to STEM majors. This is essential information because open admission results in large numbers of underprepared, low-income, minority, and ESL students (Allen & Seaman, 2010; Ashby, Sadera & McNary, 2011).

Overall, a review of the literature on the impact of student characteristics on online enrollment finds that previous empirical studies have concentrated on just a few student characteristics and/or utilized single institution or limited state/regional datasets, rather than analyzing nationally representative data. Hence, the generalizability of previous findings are limited. Further, the majority of the literature focuses on online learners generally and at four-year universities, rather than seeking specific information on community college STEM majors. But there is evidence that patterns of online enrollment differ for STEM versus non-STEM students. In particular, in a previous article (Wladis**,** Hachey, & Conway, 2012) which focused on all STEM majors in the *NPSAS* 2008 dataset, we found that there were significant differences in the way that ethnicity, gender, and non-traditional student characteristics impacted online enrollments for STEM versus non-STEM majors. While non-traditional risk factors were significant predictors of online enrollment for both STEM and non-STEM majors, they were significantly more important for STEM majors.

four-year

The purpose of this study is to determine what differences exist between community college STEM majors who take courses online and those who do not; in particular, the aim is to determine if all ethnicities, genders, and both traditional and non-traditional community college STEM majors are represented proportionally in the online environment. In addition, this study also aims to determine to what extent disproportionate representation among STEM majors in the online environment at community colleges can be explained by mediating variables such as non-traditional student characteristics (delayed enrollment, no high school diploma, part-time enrollment, financially independent, have dependents, single parent status, working full-time while enrolled); academic preparation (GPA, remedial courses ever taken, high school GPA, college credits earned in high school); SES (adjusted gross income [AGI], Pell recipient, TANF recipient, parents' highest education level); and ESL/citizenship status. We begin by testing the extent to which models that hold for four-year STEM majors need to be significantly altered if they are to be used with community college STEM majors.

Method

Data Source and Sample

This study uses the NCES National Postsecondary Student Aid Study (NPSAS) 2008 dataset[i], a nationally representative on both an institutional and student level. The data contain information on student characteristics, academics, educational history, institutional characteristics, employment, finances, and parent characteristics, and the data come from several different sources, including institutional records, government databases, and student interviews. In particular, the study focuses primarily on a sub-sample comprised of the approximately 2,300 undergraduate STEM majors who were enrolled at community colleges. An additional sub-sample consisting of the 18,400 undergraduate STEM majors who were enrolled at four-year public and not-for-profit colleges was also included for the sake of comparison with the community college subsample. We excluded 1900[ii] STEM majors who attended for-profit colleges and 3200 STEM majors who attended more than one institution type during the 2007-2008 school year from the analyses in this study, because for these groups it could not be determined whether online courses were taken at two- or four-year institutions. This dataset does not contain course-level information which would allow us to assess online versus face-to-face course outcomes; however, it does include information on a student's online course-taking during the 2007-2008 school year, which allows us to explore the relationship between certain student characteristics and online enrollment.

Measures

This study spotlights community college student characteristics which may correlate with online course enrollment for STEM majors, with a particular interest in ethnicity, gender, and non-traditional student characteristics. As a dependent variable, we used the variable in the NPSAS dataset that corresponded to whether or not a student took an online course during the 2007-2008 school year. In order to filter out only students who were STEM majors, we also used the student's major to limit the sample. For this, we employed the National Science Foundation's (NSF) definition of STEM, including math, computer, science, engineering, technology, and social and behavioral science majors[iii]. In addition, because the focus is community colleges, we used a measure of institution type to identify subsets of the data for analysis; this measure identified students as having attended public two-year institutions, public or not-for-profit four-year institutions, for-profit colleges, or a mixture of different institutions types during the 2007-2008 school year.

Gender and ethnicity were also used as independent variables. We used a measure of race/ethnicity that combines both race and Hispanic status into a single measure, and students of mixed race/ethnicity were included in the "other" category because of relatively small numbers in the sample. In some models, ethnicity and gender were combined so that the effects on gender and ethnicity could be analyzed simultaneously. For example, results for Black females and Black males were significantly different in some analyses.

The study also uses as an independent variable the non-traditional student risk index, which is a part of the NPSAS dataset. The characteristics in this risk index (Delayed enrollment; No high school diploma; Part-time enrollment; Financially independent; Have dependents; Single parent status; Working full-time while enrolled) have been historically associated with non-traditional students and further, there is evidence that this particular set of characteristics correlates with lower persistence and completion rates in college (NCES 1996, 2002). We utilize this risk index because it allows us to see how the *number* of non-traditional risk factors may influence the likelihood of online enrollment, which is essential since observational studies (e.g. Jaggars & Xu, 2010; Xu & Jaggars, 2011) that have attempted to control for self-selection into online courses have typically used only a few non-traditional student characteristics (e.g. working full-time) as controls; however, if the likelihood of enrolling in an online course goes up significantly as the *number* of non-traditional risk factors increases, this suggests that selection into online courses cannot be adequately controlled with only one or two non-traditional characteristics. We also include models that incorporate these non-traditional risk factors separately. In these models, we include individual factors in the non-traditional student index of risk, in addition to separate characteristics which determine whether a student is financially independent, and we also modify the measure of whether a student has dependents, by replacing it with a variable which measures whether the student has at least one dependent child under the age of six years old, to adjust for collinearity with age and financial independence.

Additional factors included in this study were selected because they are most often posited as possible mediating variables for differences in college enrollments and/or outcomes for minorities, female students, and non-traditional students at community colleges. These other factors include 1) academic preparation (GPA, high school GPA, whether college credits were earned in high school, and whether the student ever took a remedial course (Aragon & Johnson, 2008; Dupin-Bryant, 2004; Moore, Bartkovich, Fetzner & Ison, 2004; Morris, Wu & Finnegan, 2005; Muse, 2003)); 2) SES (AGI, whether the student was a Pell grant recipient, whether the student received federal benefits, and the parent's highest level of education (Adelman, 2006)) and 3) ESL and citizenship status (Erisman & Looney, 2007; Lopez, Gonzalez-Barrera, & Patten, 2013).

Data Analyses

This analysis used multivariate binary logistic regression models, with online course enrollment serving as the binary dependent variable and independent variables of ethnicity, gender, non-traditional student characteristics, academic preparation, SES, and ESL/citizenship status. To compare two- and four-year STEM majors, ethnicity, gender, and the NCES non-traditional student risk index were used along with institution type (two- versus four-year) as independent variables and the interaction between each of these variables and institution type was assessed with respect to its ability to predict online enrollment. Then this analysis focused on individual models on two-year students only. First separate models were run for each set of independent factors, and then a set of nested multivariate models were run to build up the final model step-by-step. The first model included ethnicity and gender in order to obtain baseline differences for all ethnic and gender groups before covariates were added. Next, non-traditional student characteristics were added because there is strong evidence of these as a mediating variable for ethnicity and gender (and because these characteristics are also of principal interest in this study) (see e.g. NCES, 1996; 2002; Wladis, Conway, & Hachey, n.d.) Following, academic preparation and SES were added as covariates in the third and fourth models respectively and ESL/citizenship status was added in the fifth and final nested model, (added last because evidence for this set of factors as mediating variables was the least supported in the literature at the time of this study). Additionally, regression was used to model the correlation between a community college STEM major's score on the non-traditional risk factor scale with their likelihood of enrolling in an online course.

Results

Ethnicity, Gender, and Non-traditional Student Characteristics as Predictors of Online Enrollment for STEM Majors at Community Colleges Versus Four-year Colleges

While our goal is to build a model of online enrollment for STEM majors at community colleges, we first analyze the extent to which models of online enrollment may be significantly different for two-year versus four-year STEM majors. If models which have already been explored for all STEM majors (Wladis, Hachey, & Conway, 2012) will work equally well for community college students, then there is little motivation for studying community college STEM majors specifically. If there are significant differences in the ways that particular factors predict online enrollment for two-year STEM majors compared to four-year STEM majors, then further exploration of models which can accurately predict online enrollment for community college STEM majors specifically becomes essential.

Binary logistic regression models were run separately on the two-year and four-year STEM majors in the *NPSAS* dataset, and the odds ratios[iv] and other relevant statistics are reported in Table 1. Then a model on the full set of two- and four-year STEM majors was run, this time including an interaction term between institution type (two-year vs. four-year) and each of the independent variables; those interactions which were significant in the full model are indicated in Table 1 as well. From Table 1, it is clear that while Hispanic STEM majors were significantly less likely to enroll online in both two- and four-year colleges, Hispanic ethnicity was a much stronger predictor of lower rates of online enrollment for STEM majors at community colleges than at four-year schools. Similarly, female STEM majors were significantly more likely to enroll online than their male counterparts at community colleges, but this trend was not true at four-year colleges, and this difference in gender as a predictor variable for the online enrollment of STEM majors at two- versus four-year colleges was mildly significant. It also is evident that while STEM majors with more non-traditional student characteristics were significantly more likely to enroll online at both two- and four-year colleges, the increasing odds of online enrollment as the number of risk factors increased was significantly stronger for STEM majors at four-year colleges than at two-year colleges. This findings suggests that non-traditional risk factors, while still important, may not be as relevant to online enrollment at community colleges (perhaps because the prevalence of non-traditional students at these institutions is already so high) as they are to online enrollment at senior colleges.

[Insert Table 1 About Here]

Full models were then run for both two- and four-year colleges, with online enrollment as the dependent variable, ethnicity/gender groups (e.g. Hispanic male), the non-traditional student risk index, academic preparation variables, SES variables, and ESL/citizenship all added to the model. For the sake of brevity, these models are not reported here (more comprehensive models will be presented in the next section); however, these models were used to generate probabilities of online enrollment for STEM majors at two- and four-year colleges by ethnicity, gender, and number of non-traditional risk characteristics for the reference group[v]. The predicted probabilities from these models of online enrollment for different subgroups of STEM majors at two- versus four-year colleges can be seen in Figures 1 and 2 respectively. The relationship between non-traditional student risk factors and online enrollment seems to be quadratic (peaking at 3-4 risk factors) for two-year STEM Majors, but strongly steep and linear for four-year STEM majors. For example, fitting quadratic and linear regression curves to the predicted probability of online enrollment for White male STEM majors gives the following results: for community colleges the R^2 value for the quadratic regression is 0.9393 (versus 0.6840 for linear regression); whereas for four-year colleges, linear regression yields an R^2 of 0.9896. The linear regression equations for each of these groups allows us to estimate the average increase in the probability of taking an online course for each additional non-traditional student risk factor: for four-year STEM majors, each additional non-traditional characteristic increases the probability of online enrollment by five percentage points, compared to only two percentage points for community college STEM majors.

[Insert Figures 1 and 2 About Here]

We note also that other patterns in Figures 1 and 2 are quite different when comparing two-year to four-year STEM majors. Specifically, for four-year STEM majors, non-traditional risk factors are the strongest predictor of online enrollment, with race and gender contributing little extra information once the number of risk factors is controlled; in contrast, for two-year STEM majors, race and gender are very strong predictors of online enrollment, with the number of non-traditional risk factors having less of an impact on online enrollment than they do for four-year STEM majors. For example, among four-year students with zero risk factors, the probability of online enrollment is tightly clustered around 10%, while for two-year students with zero risk factors, the probability is spread widely across a range of about 5-18%, based on race and gender.

Models of Online Enrollment for Community College STEM Majors

Since there are significant differences in the ways that ethnicity, gender, and non-traditional risk factors correlate with online enrollment for two-year versus four-year STEM majors, we now proceed to investigate a model of online enrollment for two-year STEM majors specifically. First we consider a model containing only ethnicity/gender groups (e.g. Hispanic males), which will allow us to determine which subgroups are underrepresented online. Then we consider a fuller model that includes a combined measure of ethnicity/gender, non-traditional student characteristics, academic preparation variables, SES measures, and measures of ESL/citizenship. For the non-traditional student characteristics, each of the seven factors included in the NCES index of risk of non-traditional students is included, with the following modifications:

1. Because financial independence is itself a combination of a number of other factors[vi], we have disaggregated financial independence into the following individual factors each tested separately: age; marital status; dependent status; and military status. (Status as an orphan

could not be included in the model because there were fewer than 30 students in this category.)

2. Because all students with dependents are by definition financially independent, and because having older dependents is highly correlated with age, we have re-operationalized the variable “has dependents” as students who have dependent children under the age of two. This definition relates more strongly to the theoretical justification for student parents having higher online enrollment rates, since infants/toddlers may require more hours of direct childcare from the parent.
3. Since all single parents by definition have dependents (and since single parent status was not a significant predictor of online enrollment once having dependents was included in the model), this factor has been removed from the final model.

The odds ratios, standard errors, and tests for significance for several models can be seen in Table 2. Individual models for each risk factor alone as a predictor of online enrollment are presented (in the cases where such models were significantly different from the null model); this allows us to consider the predictive power of that individual predictor alone, without yet controlling for other variables. Then a model incorporating all of the non-traditional characteristics as predictors of online enrollment is included in Table 2; this allows us to see the relative predictive power of each individual non-traditional characteristic when all other non-traditional student characteristics are controlled. And finally, a model is presented which includes all of the non-traditional student risk factors along with ethnicity/gender, academic preparation, SES, and ESL/citizenship status; this allows us to determine which of these factors are significant predictors of online enrollment for community college STEM majors, when all other factors are controlled.

[Insert Table 2 About Here]

Specifically, the following patterns become apparent: Black and Hispanic male STEM majors are highly significantly underrepresented online in comparison to White female STEM majors at community colleges. To a lesser extent, White males and Hispanic females are also underrepresented. Once controlling for non-traditional student characteristics, academic preparation, SES, and ESL/citizenship, Black and Hispanic males remain significantly underrepresented. The non-traditional characteristics, which individually are significant predictors of online course enrollment for community college STEM majors, are: an age of 24 or older, being married, working full-time, and having dependent children under the age of two. However, when all non-traditional characteristics and other factors are simultaneously controlled, only being over the age of 24, working full-time while enrolled, and having dependent children under the age of two remained significant predictors of online enrollment for community college STEM majors. In addition, having taken a remedial course at some point in college was also a mildly significant predictor of online enrollment for community college STEM majors. In order to find the most parsimonious model, we did backward elimination on the full model given in Table 2, using $\alpha=0.20$ as the threshold for retaining variables in the model; because of space constraints, we do not report detailed model coefficients for the most parsimonious model here, but the variables which were retained in this model were: ethnicity/gender, age, dependent children under the age of two, and working full-time while enrolled.

Predicted probabilities for the most significant risk factors, based on the full model, can be seen in Figure 3. Once all other factors are controlled , only about one-fifth of younger students without full-time jobs and younger children enroll in online courses, while in contrast almost half of all older students with full-time work and young children enroll in online courses. Even when controlling for age (and other factors), having small children at home and working full-time while enrolled remain significant predictors of online enrollment for STEM majors at community colleges.

[Insert Figure 3 About Here]

Limitations

This study only looks at the probability that a student majoring in STEM took an online course. However, the individual courses taken by each group of students, and the extent to which the courses taken were in their major discipline, were not available in the national dataset. Additionally, some subgroups of interest in this study were relatively small, and thus it was not possible to draw firm conclusions about every factor; this suggests that further studies with larger samples sizes could assist in explicating the significance of some of these factors.

Also, while this analysis controlled for a number of different student characteristics that may predict online enrollment, it did not control for them all. This study focused in particular on student characteristics; however, there are other factors, such as institutional-level policies and resources relevant to online learning (e.g. which courses are offered online, what resources are available for online students) which likely also impact student decisions to enroll online. Future studies which explore these factors in addition to the ones explored here, may shed more light on factors that affect online enrollment for community college STEM majors.

Discussion and Implications

When modeling online enrollment at two-year in comparison to four-year colleges, the impact of ethnicity and gender as predictor variables was stronger than the impact of non-traditional risk factors. For four-year college STEM majors, non-traditional student risk factors were strongly positively linearly correlated with online enrollment, with each additional risk factor increasing a STEM major's probability of enrolling online by five percentage points, whereas for two-year STEM majors, each additional risk factor increased the likelihood of online enrollment by only three percentage points, and the impact of non-traditional risk factors peaked around 3-4 risk factors for this group, instead of steadily increasing in a linear fashion. This suggests that models of online STEM major enrollment which are based largely on four-year college students may be insufficient to model student behavior at community colleges and that further research on larger samples of community college students is needed in order to determine what differences may exist between the factors which influence online enrollment at community colleges and four-year colleges.

In particular, this study shows that not all groups of STEM major students are equally represented in the online environment at community colleges: Black and Hispanic males in particular are not proportionally represented in the online environment even after controlling for non-traditional student characteristics, academic preparation, SES, and ESL/citizenship status. This reinforces patterns observed more generally in online courses, in which non-white minorities are underrepresented in comparison to whites online and in which women are represented in higher proportions than in the general college population (Angiello, 2002; Jaggars & Xu, 2010; Xu & Jaggars, 2011; Wladis, Hachey & Conway, n.d.). Also reinforcing patterns observed in general online courses, female STEM majors are represented in higher proportions in online courses than in face-to-face courses at community colleges, suggesting that documented issues such as female stereotype threat and implicit bias may play out differently in online STEM courses because of the higher representations of women. Online STEM courses may provide a good opportunity for recruiting and retaining female STEM majors at community colleges. Further research is needed to explore this possibility.

Community college STEM major students with non-traditional student characteristics were significantly more likely to enroll in online courses, even when ethnicity, gender, academic preparation, and SES were controlled. This suggests that general patterns of non-traditional students enrolling in online courses at higher rates (Pontes, 2010; Wladis, Hachey & Conway, n.d.) also hold for STEM majors at community colleges, where a larger proportion of students are non-traditional. In particular, community college STEM majors who were 24 years of age or older, those who worked full-time while enrolled, and those with dependent children under the age of two were particularly likely to take online courses, and these factors remained in the most parsimonious model of online enrollment for STEM majors. This suggests that non-traditional students, who are not enrolling or persisting in college (and in STEM degrees) at the same rates as their more traditional peers, may be more likely to enroll in courses if they are offered online. This is an additional key area for future research to explore.

Until more research is available which clarifies the extent to which online course access impacts student decisions to enroll in college courses, institutions should be cautious about limiting access to online courses because of the potentially disproportionate impact this may have on certain non-traditional groups of students (i.e. older students, students working full-time, and students with small children). For example, many community colleges, concerned about documented higher attrition rates in online courses, have instituted screening procedures that allow only certain students to enroll online (e.g. by barring or discouraging certain students from enrolling online), have limited which courses can be offered online (for example, prohibiting developmental courses from being taught online), or have limited the number of courses that a student may take online (Liu, Gomez, Khan, & Yen, 2007). If STEM students who work full-time or have small children are enrolling in online courses because they are the only types of courses with the flexibility needed to meet their schedule, then these same students may not enroll in an alternate face-to-face course if the online course they need is not available – they may simply choose not to enroll in college at all that semester, or they may choose to enroll in fewer courses. If this occurs, it could have serious implications for college persistence and STEM degree completion for this group, since academic momentum (e.g. the rate at which students complete course credits toward a degree) has been shown to be a significant predictor of college completion (Attewell, Heil & Reisel, 2012). Until more research is available about the impact of these policies on student enrollment decisions online, colleges may need to be cautious about implementing rules or procedures that limit the availability of online courses. Institutions will need to carefully consider how to balance concerns about online retention with concerns about potentially restricting access to college courses for the older students, full-time employees, and parents of small children who are most likely to take courses online.

This research also suggests that any observational studies which aim to determine the effect of the online environment on course outcomes for STEM majors at community colleges will need to include a number of factors as covariates to control for hidden self-selection bias. It seems particularly important for many of the non-traditional student risk factors such as working full-time, having young children, and being financially independent, as these factors are often not routinely collected by institutional research departments and are often not included in statistical analyses of online versus face-to-face course outcomes. In particular, including just a single one of these non-traditional student characteristics (as many studies who attempt to control for these factors have done) may not be sufficient to capture all of the bias due to non-traditional factors that are impacting online student enrollment; the rate of online course enrollment increases significantly as the number of non-traditional student characteristics increases (at least for the first three or four risk factors). Furthermore, certain academic preparation characteristics that are also common among non-traditional students, such as a history of remedial course taking, may also be significant sources of self-selection bias.

The dataset used in this study was not appropriate for assessing online course outcomes, because it did not include course-level data on online and face-to-face courses. However, future studies could be conducted on datasets which include student grades in comparable online and face-to-face sections of specific STEM courses, in addition to student characteristics. If many of the non-traditional student characteristics cited as significant predictors of online course enrollment for STEM majors in this study were included as covariates or used in a matching procedure, then resulting differences in online versus face-to-face course retention or passing rates could be more accurately estimated.

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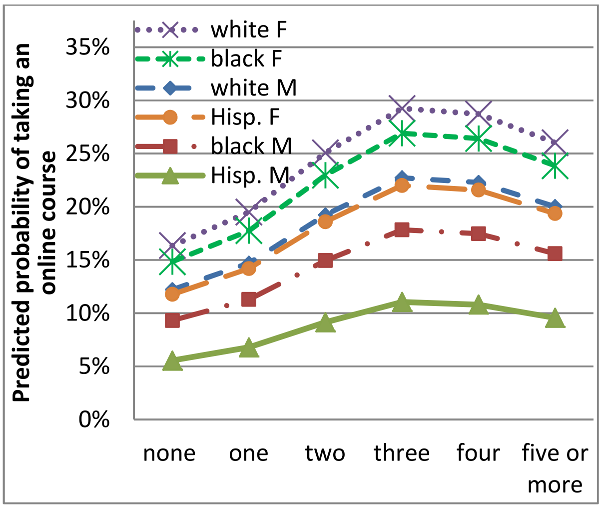

Figure 1 Predicted probability of taking an online course (CC, *Table 1*) by ethnicity, gender, & risk index

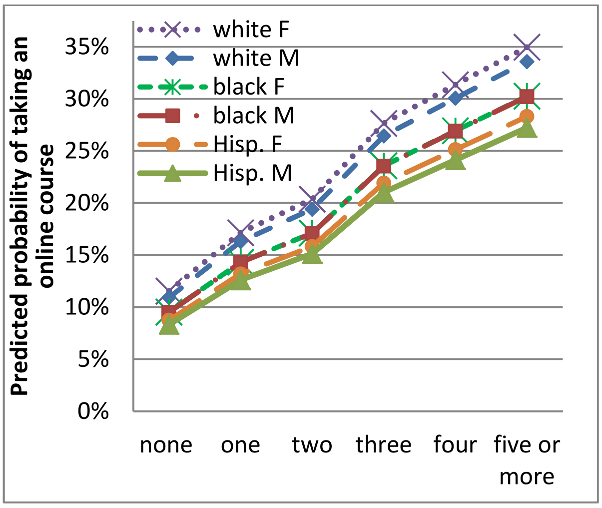

Figure 2 Predicted probability of taking an online course (4-yr, *Table 1*) by ethnicity, gender, & risk index

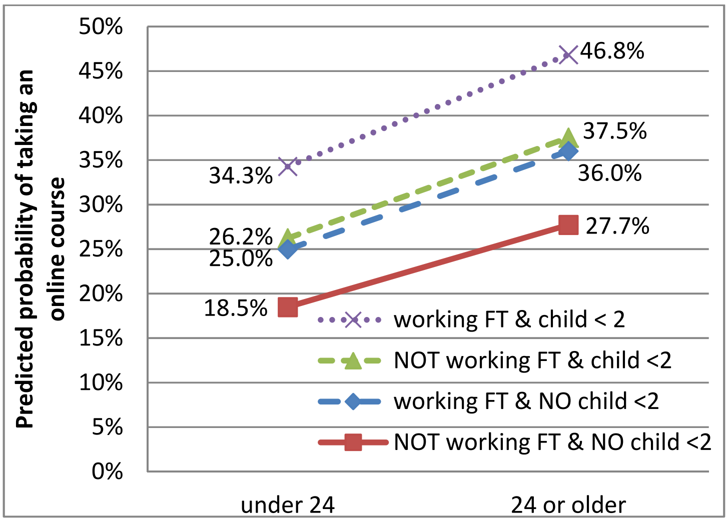

Figure 3 Predicted probability of taking an online course (CC, *Table 2*) by age, FT employment while enrolled & dependent child under 2 yrs.

Table 1 Logistic Regression Models for Online Course Enrollment, for two-year versus four-year STEM majors (Odds Ratios Reported)

	two-year		four-year		interaction[c]
Intercept	0.1928		0.0989	***	
	(0.0329)		(0.0065)		
Race/ethnicity					
Black or African American	0.7372	*	0.8634		*
	(0.1127)		(0.0985)		
Hispanic or Latino	0.5105	***	0.8183	·	***
	(0.1011)		(0.0912)		
Asian	0.946		0.8496		
	(0.2123)		(0.1264)		
Other	0.8434		0.9328		
	(0.2243)		(0.1674)		
Gender					
Female	1.5506	***	1.0906		***
	(0.1753)		(0.0711)		
Index of risk and nontraditional students[a]					
One	1.2281		1.632	***	***
	(0.2682)		(0.1519)		
Two	1.6723	*	2.1043	***	***
	(0.3516)		(0.2545)		
Three	1.8964	**	3.3627	***	***
	(0.3996)		(0.3919)		
Four	2.1323	**	4.4283	***	***

	(0.5064)		(0.6237)		
Five or More	1.9674	***	5.1037	***	***
	(0.3727)		(0.9264)		
coarsened N[b]	3,200		18,400		
pseudo R^2 (Nagelkerke)	0.0428		0.0525		
AIC	1,057,052		1,829,403		
p-value for overall fit Wald *F*-statistic	0.0000	***	0.0000	***	

Source: U.S. Department of Education, National Center for Education Statistics, 2007-08 National Postsecondary Student Aid Study (NPSAS:08).

Notes: Standard errors are in parentheses. Variance estimation was computed using Balanced Repeated Replication with 200 replicates. The weight variable used in this table is WTA000.

[a]This index measures how many of the following seven characteristics apply to a given student: Delayed enrollment; No high school diploma; Part-time enrollment; Financially independent; Have dependents; Single parent status; Working full-time while enrolled

[b]Per NCES Standards, the true sample size has been modified to minimize disclosure risk of individual survey responses.

[c]This column indicates whether the interaction between the factor and institution type (two-year vs. four-year) was significant in the overall model including two- and four-year STEM majors. A test of overall model fit, by testing the model with the interaction of institution type with all of the other independent variables was significant: using the weighted deviance difference method for comparing the *F* statistic of both the model with the interactions and the one without, the model with the interactions was a significantly better fit with *p*=0.0004.

· *p*<0.10, * *p*<0.05, ** *p*<0.01, *** *p*<0.001

Table 2 Logistic Regression Models of Online Course Enrollment for STEM Majors at Community Colleges, with detail for Ethnic/Gender groups and Non-Traditional Student Characteristics Shown Separately (Odds Ratios Reported)

	ethnicity/ gender	age	child under 2	married	working FT	all risk factors	full model
Intercept	0.4558 ***	0.2393 ***	0.3059 ***	0.2759 ***	0.2589 ***	0.2268 ***	0.2143 ***
	(0.0513)	(0.0443)	(0.0362)	(0.0369)	(0.0407)	(0.0255)	(0.0786)
Race/ethnicity *(Ref. gp. White female)*							
Asian Female	0.8335						1.1253
	(0.2899)						(0.4380)
Black female	0.8947						0.9824
	(0.2334)						(0.2671)
Hispanic female	0.6216 ·						0.7483
	(0.1735)						(0.2409)
Other female	0.7163						0.6000
	(0.3546)						(0.3765)
White male	0.6997 *						0.7289 ·
	(0.1080)						(0.1253)
Asian male	0.6068						0.6728
	(0.2004)						(0.2556)
Black male	0.4769 **						0.5383 *
	(0.1139)						(0.1417)
Hispanic male	0.2650 **						0.3282 *
	(0.1143)						(0.1604)

Other male	0.7431						0.7441
	(0.2498)						(0.2940)
delayed enrollment							
yes						0.9327	0.9697
						(0.1214)	(0.1435)
HS diploma							
no						1.0107	0.9855
						(0.2035)	(0.1953)
PT enrollment							
yes						0.8992	0.8409
						(0.1177)	(0.1203)
Age							
24 or above		1.6941 ***				1.5218 *	1.6900 *
		(0.4004)				(0.2496)	(0.3432)
Dependents							
dependent child under 2 years old			1.7562 *			1.4298	1.5663 ·
			(0.8101)			(0.3417)	(0.4203)
Marital status *(Ref. gp.: Single, Divorced, or Widowed)*							
Married				1.6631 ***		1.2600	1.1225
				(0.4357)		(0.1972)	(0.2070)
Military type *(Ref. gp.: None or Reserves)*							
Active duty or Veteran						0.8778	0.8759
						(0.2076)	(0.2256)

working FT while enrolled			
yes	1.5545 ***	1.3910 *	1.4782 **
	(0.3620)	(0.1822)	(0.2200)
Grade point average			1.0002
			(0.0008)
Remedial courses: Ever taken			
Yes			1.2504 ·
			(0.1620)
Grade point average in high school[a]			
2.5-2.9			0.9052
			(0.2011)
3.0-3.4			1.0236
			(0.2223)
3.5-4.0			1.2443
			(0.3014)
{Skipped}			1.1858
			(0.2738)
Earned any college credits in high school			
Yes			1.3250
			(0.2367)
Aid package with Pell grants			
Yes			1.0516
			(0.1566)

Received federal TANF benefits							
Yes							1.2157
							(0.7146)
Adjusted Gross Income (AGI)							1.0000
							0.0000
Parent's highest education level (*Ref gp: Associate’s degree, Technical/vocational training, or Some college*)							
Did not complete high school							0.8338
							(0.2205)
High school diploma or equivalent							0.9165
							(0.1677)
Bachelor's degree or higher							1.0685
							(0.1546)
Do not know parent's education level							1.2296
							(0.3414)
English is the primary language							
No							0.9859
							(0.2460)
Citizenship *(Ref. gp.: US citizen)*							
Resident alien							0.8169
							(0.1984)
Foreign or international student							2.6315
							(2.5342)
coarsened N[b]	3,200	3,200	3,200	3,200	3,200	3,200	3,100
pseudo R^2 (Nagelkerke)	0.0261	0.0186	0.0039	0.0135	0.0130	0.0319	0.0721
AIC	1,053,55	1,067,63	1,068,06	1,070,04	1,062,13	1,038,72	967,57

	3	9	3	9	6	8	6
p-value for overall fit Wald *F*-statistic	0.0045 **	0.0000 ***	0.0170 *	0.0002 ***	0.0002 ***	0.0001 ***	0.0002 ***

Source: U.S. Department of Education, National Center for Education Statistics, 2007-08 National Postsecondary Student Aid Study (NPSAS:08).

Notes: Standard errors are in parentheses. Variance estimation was computed using Balanced Repeated Replication with 200 replicates. The weight variable used in this table is WTA000.

[a]H.S. G.P.A. is missing for those students who took neither the ACT nor the SAT and/or for students 30 years or older.

[b]Per NCES Standards, the true sample size has been modified to minimize disclosure risk of individual survey responses.

· $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

[i] For more detailed information about the methodology of this dataset, see the Field Test Methodology Report, which can be found at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=200801.
[ii] All sample sizes have be rounded to the nearest hundred, as per NCES requirements, to minimize disclosure risk of individual survey responses.
[iii] In total, only about 500 of the 3100 STEM majors used in this study were social science majors, with the remaining majoring in the “hard” sciences and technology. Exact wording of the survey items used for students to report their major can be found in the Methodology report from the NCES on the NPSAS 2008 dataset at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011188.
[iv] Odds ratios give the ratio of the odds of the outcome for two different groups. So if the odds for both groups are the same, the odds ratio will be equal to one. If the odds of a particular group for a given outcome are higher than for the reference group, the odds ratio will be greater than one, and if the odds of a particular group for a given outcome are lower than for the reference group, the odds ratio will be less than one. For example in this analysis, the odds ratio for Hispanic male STEM majors at community colleges is roughly 0.33 when the reference group is White female STEM majors.
Therefore, at community colleges, the odds of a Hispanic male STEM major enrolling in an online course is roughly one third those of the odds of a White female STEM major enrolling in an online course, all other factors being equal (e.g. gender, number of non-traditional student characteristics). The predicted probabilities of a Hispanic male and a White female STEM major enrolling in an online course (for all other characteristics in the reference group) is 6.8% and 18.2%, respectively. This yields the odds ratio 0.33 $((6.8/93.2)/(18.2/81.8)\approx 0.33)$. We note that this is not the same as the relative risk ratio, or the ratio of the probability of the event of enrolling in an online course $(6.8/18.2\approx 0.37)$. When probabilities are small, odds ratios are close to relative risk ratios; however, when probabilities are large, odds ratios and relative risk ratios are quite different.
[v] The reference groups for each of the academic preparation, SES, ESL and citizenship variables were the same in these models as they are in the models presented in *Table 2*.
[vi] A student is designated as financially independent if they have one of the following factors: 1) are 24 years or older; 2) are married; 3) have dependents; 4) are active duty or veteran military; 5) are orphans or wards of the court. Students under 24 years of age not meeting any of these conditions but also not receiving parental support may be classified as independent by campus financial aid officers, although the proportion of financially independent students who fall into this category is relatively small.