Academic Success for STEM and Non-STEM Majors

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Abstract

Enrollment in STEM majors has improved recently, but there continues to be concern over retention in those majors, especially of women and minority students. The purpose of this study is to develop an integrated understanding of how multiple predictor variables affect student degree attainment and to ascertain how the variables' impact is regulated by whether students are in STEM or non-STEM majors. Six-year cohort retention/graduation outcomes are predicted for all students in STEM and non-STEM majors, and are adjusted separately for whether students remain in, or shift into or away from, STEM majors. Long-term retention/graduation is predicted significantly by cumulative grade point average, financial need, aid (work-study, loan, and gift), gender, ethnicity, years living on campus, high school rank (HSR), ACT composite, out-of-state residence, and STEM status. For students starting out in non-STEM majors, six-year graduation/retention also is predicted significantly by learning community participation and whether the student switches to a STEM major.

1. Literature Review

Previous research (Daempfle, 2003; McShannon, 2001; Seymour & Hewitt, 1997) has shown concern for the number of students who choose and maintain a science major in colleges and universities. Astin and Astin (1993) used four-year longitudinal data from over 27,000 students and multivariable analyses to study how institutional traits and background characteristics of students affect their interest in studying science and majoring in science-related fields. They found that the number of students majoring in science, mathematics, and engineering declined from the freshman year to the senior year, from 28.7% to 17.4%, a 40% relative decline. Individual mathematics courses taken and overall college preparation played a large role in students persisting in those majors.

Subsequently, enrollment of students in Science, Technology, Engineering, and Mathematics (STEM) fields has increased somewhat (Huang, Taddese, & Walter, 2000; Seymour, 2002; Toulmin & Groome, 2007), but not at a pace to meet the goal of a leading business organization, Tapping America's Potential (TAP), to double the number of STEM graduates by 2015 (Reid, 2008).

While interest and ability are major considerations in students choosing a STEM major, Takruri-Rizk et al. (2008) found that having family members in the engineering or technology industry also played an important part in students' degree choice. It is more difficult to understand why students may not be drawn to STEM fields. Robinson (2003) indicated that students who took an advanced placement (AP) course in science or calculus selected STEM careers at a higher rate than they picked other careers. But even though more students may enroll in a STEM major, persistence of students in STEM majors remains a problem (Daempfle, 2003). Seymour (1995) noted that the quality of teaching in science classes has an impact on persistence. Some attrition has been explained by students being unprepared (Seymour & Hewitt, 1997; Strenta, Elliott, Adair, Matier, & Scott, 1994), yet even well-prepared students have been found to leave science, mathematics, and engineering majors because of what they perceived as poor instruction, undesirable curricular structure using one-way lectures, and faculty who valued their research above teaching (Seymour & Hewitt, 1997). Springer, Stanne, and Donovan (1999) summarized a number of efforts to improve STEM courses, such as small-group learning.

1.1 Underrepresented students (women and minorities) in STEM majors

Maintaining a diverse enrollment to include women and minorities in STEM majors is also a concern (Tan, 2002). The Astin and Astin (1993) Higher Education Research Institute (HERI) studies documented higher loss rates for students in STEM majors among Hispanic, African American, or Native American students, using data collected by the Cooperative Institutional Research Program (CIRP) at UCLA. National data from the 1980s found poor persistence by minority students compared with majority students in engineering majors (Morrison & Williams, 1993) and in science and mathematics (Culotta, 1992).

However, data from the National Science Foundation have indicated some narrowing of the gap in representation of women and minorities among science and engineering bachelor's degree recipients in the United States (Hill, 2007; Huang et al., 2000). Yet underrepresentation of women and minorities is reaffirmed in a report by Cassell and Slaughter (2006), who cite 2004 data from the National Center for Education Statistics indicating a continuing gap in degree attainment by students in STEM enrollment and degree attainment. The same authors cite National Science Board statistics indicating the underrepresentation of women in STEM disciplines. Chubin, May, and Babco (2005) noted that, while their representation is improving in some STEM majors, women and minorities are still underrepresented in engineering majors. A study by the American Council on Education (Anderson & Kim, 2006) indicated increasing six-year persistence/graduation for African-American and Hispanic STEM majors, with nearly two-thirds (62.5%) graduating and 28.8% still persisting.

Some research has focused on why female students who enroll in STEM fields are not retained in those disciplines. Some suggest the decline might be due more to the climate in the academic setting, or what students perceive as the climate in the subsequent work setting. Blickenstaff (2005) saw a "sex-based filter," with no one issue being found to cause the non-retention. Erwin and Maurutto (1998) found through longitudinal interviews of undergraduate women that it was not ability or achievement, but rather social-psychological variables and a chilly climate that led to women's departure from the sciences. In addition, despite their overall high ability levels, most women viewed their departure as a failure, and what they perceived as "lack of ability, drive and/or potential as casual factors" (p. 65). Earlier research by Strenta et al. (1994) found that low grades were the most common predictor for all students leaving science and engineering courses; holding grades constant, gender was not a significant predictor of persistence in engineering and biology, but was such in a category that included physical sciences and mathematics.

Ramsey and McCorduck (2005) described the declining number of women in information technology (IT) majors in the United States and attributed much of the decline to the working climate of IT majors. However, more may be involved than what students anticipate as a working environment in a career when they choose a major. Busch (1995) found that "the most important predictor of computer attitudes is previous computer experience and encouragement" (p. 152). Yet, Ramsey and McCorduck found no gender differences on subscales of computer anxiety, computer confidence, and computer liking.

Women in STEM majors have been reported to be less confident in the classroom. Rogers (1993) noted that, aside from intellectual development that was gained from the classroom, women suffered a loss of self-confidence and lower career aspirations. Henes (1994) noted that the classroom experience can be much different for women, who may become less confident and less likely to contribute in class. Takruri-Rizk et al. (2008) reported that female students were more comfortable in smaller, practical sessions than in large lecture situations. Felder, Felder, Mauney, Hamrin, and Dietz (1995) found that women in engineering entered the program academically as strong as men, but with greater anxiety and less self-confidence. Remedies suggested were cooperative learning and social and academic support systems.

Fenske, Porter, and Dubrock (2000) found that students in science, engineering, and mathematics majors persisted and graduated at higher rates but took longer to graduate than did non-STEM majors. The same researchers also found that underrepresented students in science, engineering, and mathematics majors with financial need dropped out at a higher rate compared with other science, engineering, and mathematics students.

Overall, the data related to women's enrollment and graduation in STEM majors are conflicting. Chubin et al. (2005) noted that since 1966, the number of bachelor's degrees awarded to students in STEM majors received annually by men has remained relatively stable, at about 200,000, but by 2001 the number of bachelor's degrees received by women increased and reached parity with men in number of degrees awarded. Yet this trend does not seem to include information technology (IT) majors. Chabrow (2007) noted a drop in IT majors since 2000. Similarly, Singh, Allen, Scheckler, and Darlington (2007) reported that the enrollment of women in computer-related majors declined from 1994 through 2005.

1.2 Variables affecting retention and graduation of STEM students

General student retention studies offer some guidance as to why STEM majors are retained. Previous research on background characteristics included gender (Astin, 1993; Leppel, 2002; Stage & Hossler, 1989), race/ethnicity (Fischer, 2007; Pascarella & Terenzini, 1983, 2005), academic success (Cabrera & La Nasa, 2000; Milem & Berger, 1997; St. John, Hu, Simmons, & Musoba, 2001), financial situation (Olenchak & Herbert, 2002), parents' education (Pascarella, Pierson, Wolniak, & Terenzini, 2004; Ting, 2003), and family structure (Desimone, 1999). Students' previous educational experiences (Astin & Oseguera, 2005) and social interactions (e.g., McDonough, 1994; Reason, Terenzini, & Domingo, 2007) also are among the relevant background characteristics.

Financial aid also plays an important role in supporting student attendance (DesJardins, Ahlburg, & McCall, 2002; Hu & St. John, 2001). Previous studies on financial aid and academic success and retention have focused on the equalization of educational opportunities by eliminating income differences (St. John & Noell, 1989) or in promoting persistence (St. John, 1990; St. John, Kirshstein, & Noell, 1991).

In addition to background characteristics and financial assistance, institutional experiences contribute to student retention and success. On-campus residence can aid student retention (Pascarella & Terenzini, 2005; Pascarella, Terenzini, & Blimling, 1994). On-campus residence can also provide higher personal and social gains that foster increased involvement and connection to the institution (Astin, 1993; Flowers, 2004). Being part of a learning community can also contribute to a further sense of campus engagement which, in turn, can contribute to retention (Astin, 1993; MacGregor & Smith, 2005).

This study follows Astin's I-E-O model (Astin, 1993) by considering the "Input," "Environment," and "Output" variables related to student persistence through degree attainment. "Inputs" refers to the characteristics of the student at the time of initial entry to the institution; "environment" refers to the various programs, policies, faculty, peers, and educational experiences to which the student is exposed; and "outcomes" refers to the student's characteristics *after* exposure to the environment (p. 7).

In using this model, the study explores student background, student financial situations, and institutional variables to assist in developing a theoretical model that helps to better understand the complexities of the college completion process (DesJardins et al., 2002; Ishitani, 2006). This study uses many of the same independent variables to explore six-year persistence to degree completion. This approach follows other examples in the literature, which develop models that compare the attrition and degree completion processes (DesJardins et al., 2002; Ishitani, 2006).

2. Research questions

The researchers were interested in building models to predict STEM and non-STEM student retention/graduation by the end of the sixth year, the retention of underrepresented students in both STEM and non-STEM majors, and the effect on retention/graduation of changing from or to a STEM major. Our six-year framework for measuring student retention/graduation is predicated on that amount of time being used as the federal government standard (Graduation Rates, n.d.) of "150 percent of normal time to completion." The research questions that guided the study were:

1. What background characteristics, ability measures, financial support systems, and academic support mechanisms help explain retention and/or graduation for students in both STEM and non-STEM majors by the end of the sixth year?

2. Are the predictors of retention and/or graduation by the end of the sixth year different for STEM and non-STEM majors?

3. Are underrepresented (female or minority) students in STEM majors more likely than traditional (majority male) students in STEM majors to be retained/graduated in six years when controlling for selected background, environmental (i.e., characteristics of the college education experience), financial, and academic measures?

3. Methods

This study examined retention and graduation of full-time freshmen entering fall 2000 at a Midwestern research university with very high research activity as defined by the Carnegie Foundation for the Advancement of Teaching (Carnegie Foundation for the Advancement of Teaching, 2005) with an enrollment of just over 20,000 undergraduate students. Student information that included demographic, environmental, and academic grade and ability measures (HSR, ACT composite score, cumulative grade point average) were obtained from the University Registrar's student information file. ACT subscores were not used in this analysis, as our interest lay in determining the impact on student success of overall student ability, rather than ability in specific areas. Free Application for Federal Student Aid (FAFSA) data were obtained from the University Financial Aid Office.

The population for the study included all first-time, full-time enrolled students (N = 4,271) in Fall 2000. The study measured retention from the entry term (Fall 2000) through the sixth year or graduation prior to fall 2007.

Gender distribution is 54.8% male and 45.2% female, with 86.5% non-Hispanic White students, 3.0% Asian-American/Pacific Islander, 2.5% non-Hispanic Black, 2.4% Hispanic, < 1% American Indian/Alaska Native, and 5.4% non-reported ethnicity. Few (1.9%) reported being non-citizens. The great majority (74.5%) come from within the state.

The study was completed in stages. Some preliminary work segmented STEM majors and non-STEM majors to determine the extent to which each group switched from their initial major. A first regression analysis then attempted to identify general predictors of retention/graduation through the sixth year. Two subsequent regression equations examined STEM majors and non-STEM majors separately to determine predictors of retention/graduation through the sixth year for each group. In doing so, the authors have attempted to avoid what Terenzini, Cabrera, and Bernal (2001) refer to as segmentation in the research by using as much available data as possible.

Logistic regression models (Agresti, 2002; Agresti & Finlay, 2009; Green, 2003; Hosmer & Lemeshow, 2000) were estimated to predict six-year graduation/retention. These models are appropriate because of the dichotomous nature of the dependent variable, and provide estimates of the effect of each predictor variable on the outcome variable controlling for the other predictor variables in the model. Model validity is assessed by: (a) parameter estimates expressed in terms of odds ratios that measure the probability in our model of students succeeding relative to their probability of not succeeding, adjusted for the other predictors, (b) the value of Nagelkerke's pseudo-R^2 statistic, which ranges from 0 to 1 and provides an approximate equivalent to the least-squares R^2 coefficient of determination but cannot be interpreted as a proportion of explained variation, and (c) the number and proportion of observations classified correctly or incorrectly, based on a "cut value" that sets the threshold for classifying an individual student outcome as success or non-success as a function of the model's parameter estimates. Tables summarizing the results of logistic regression model estimation also present for each parameter estimate (B) Wald $\chi 2$ statistics, which are equivalent to partial *F*-tests in least-squares regression and for which a value above 4 indicates a statistically significant result, with corresponding values of the parameter estimate's standard error (*S.E.*), degrees of freedom (*df*) and significance level (*Sig.*).

3.1 Variables in the study

Variables used were defined by Astin's I-E-O model. Background characteristics in the model were: (a) gender, (b) ethnicity, (c) in-state residency, (d) total high school language credits, (e) high school rank (HSR) (a motivation and ability measure), and (f) ACT composite score (an ability measure). Environmental variables included: (a) the number of years the student lived on campus while enrolled, (b) membership in a University learning community, (c) average loan aid, (d) average gift aid, (e) average work study aid, (f) average budgeted need, and (g) major while at the University, including STEM or non-STEM delineation. These variables, together with cumulative grade point average (GPA) for the last registered term, were used to predict the dependent variable outcome, six-year retention/graduation.

Table 1 provides information on the dependent and independent variables in the model. The dependent variable is dichotomous (1 = retained or graduated within six years, 0 = not retained and not graduated within six years). Table 2 reports descriptive statistics for reten-

Variable	*N*	*Mean*	*SD*
Six-year retention/graduation (dependent variable)*	4,271	0.69	0.46
Underrepresented student (women and/or minority)*	4,271	0.50	0.50
Number of years lived on campus while enrolled	4,270	1.62	1.17
Learning community member*	4,271	0.35	0.47
High school rank	4,271	73.95	17.98
ACT composite score	4,176	24.50	4.02
Average loan aid (x $1,000)	4,271	5.10	4.67
Average gift aid (x $1,000)	4,271	2.45	3.34
Average work study aid (x $1,000)	4,271	0.25	0.99
Average budgeted need (x $1,000)	4,271	4.83	5.17
Cumulative GPA for Last Registered Term (LRT)	4,268	2.69	0.87
Total high school language credits	4,271	5.84	2.50
In-state resident*	4,271	0.74	0.44
STEM major	4,271	0.48	0.50
Started/remained a STEM major (first regression model only)*	2,038	0.73	0.44
Started/remained a non-STEM major (second regression model only)*	2,233	0.92	0.28

Note: All variables save the last two were used in each model.
* Mean for these variables is effectively a percent.

Table 1. Dependent and independent variables for the two logistic regression models (*N* = 4,271)

STEM Group	N	Six-year Retention	Mean F00 GPA	Mean Sp01 GPA	Mean Sp01 Cum. GPA	Last Term Cum. GPA	Mean ACT Cum.	Mean High School Rank
Not a STEM major the first term	2,233	66.4%[a]	2.66	2.66	2.70	2.68	23.38[f]	70.16[h]
Stayed a non-STEM major	2,045	65.7%[b]	2.65	2.66	2.70	2.69	23.35	70.17
Changed to a STEM major	188	73.9%[b]	2.71	2.64	2.69	2.66	23.68	70.02
STEM major the first term	2,038	70.9%[a]	2.62	2.61	2.66	2.71	25.74[f]	78.11[h]
Stayed a STEM major	1,485	70.1%	2.71[c]	2.66[d]	2.73[e]	2.71	26.10[g]	79.18[i]
Changed to a non-STEM major	553	73.1%	2.40[c]	2.49[d]	2.49[e]	2.69	24.77[g]	75.23[i]
Total cohort	4,271	68.6%	2.64	2.64	2.68	2.69	24.50	73.95

[a] Statistically significant difference; $\chi^2 = 9.965$, $df = 1$, $p = .002$.
[b] Statistically significant difference; $\chi^2 = 5.209$, $df = 1$, $p = .022$.
[c] Statistically significant difference; $t = 7.309$, $df = 1107$, $p < .001$.
[d] Statistically significant difference; $t = 3.802$, $df = 1026$, $p < .001$.
[e] Statistically significant difference; $t = 6.164$, $df = 1106$, $p < .001$.
[f] Statistically significant difference; $t = 19.707$, $df = 4070$, $p < .001$.
[g] Statistically significant difference; $t = 6.786$, $df = 998$, $p < .001$.
[h] Statistically significant difference; $t = 14.879$, $df = 4262$, $p < .001$.
[i] Statistically significant difference; $t = 4.723$, $df = 925$, $p < .001$.

Table 2. Academic characteristics for the fall 2000 cohort students grouped by first term and last term enrollment in a STEM major.

tion, academic success, ACT scores, and HSR of the fall 2000 cohort, grouped by whether they enrolled and stayed in a STEM major. Three logistic regression models were estimated to examine research questions for the study. The first model (Table 3) focused on the first research question regarding predictors of six-year retention/graduation. Subsequently, two separate regression models (Table 4) were estimated, one predicting retention for students in STEM majors, and the other predicting retention for students in non-STEM majors.

Independent variables included background characteristics, academic measures, financial measures, and whether the student was enrolled in a STEM major. Background characteristics included (a) underrepresented (female or minority) for STEM gender and ethnicity (1 = underrepresented, 0 = traditional), (b) in-state residency (1 = in-state, 0 = out of state), and (c) total high school language credits.

Three variables provided academic information: (a) ACT composite score, a measure of academic ability, (b) HSR, a measure of academic ability and motivation, and (c) GPA measured for the last registered term within the six years.

Two environmental variables of interest to

Variables in the Equation	*B*	*S.E.*	*Wald* χ^2	*df*	*Sig.*	*Odds Ratio*
Underrepresented student (women and/or minority) (1 = yes)	0.557	0.108	26.809	1	<0.01	1.746
Number of years lived on campus while enrolled	0.436	0.049	79.388	1	<0.001	1.546
Learning community member (1 = yes)	-0.182	0.108	2.823	1	0.093	0.834
High school rank	-0.015	0.003	19.454	1	<0.001	0.985
ACT composite score	-0.095	0.015	38.548	1	<0.001	0.909
Average loan aid (x 1,000)	0.110	0.012	89.878	1	<0.001	1.116
Average gift aid (x 1,000)	0.086	0.020	18.888	1	<0.001	1.090
Average work study aid (x 1,000)	0.677	0.123	30.229	1	<0.001	1.968
Average budgeted need (x 1,000)	-0.060	0.012	26.657	1	<0.001	0.942
Cumulative GPA for Last Registered Term	2.953	0.108	751.092	1	<0.001	19.173
Total high school language credits	0.017	0.021	0.651	1	0.420	1.017
In-state student (1 = yes)	-0.751	0.117	41.352	1	<0.001	0.472
STEM major first term (1 = yes)	-0.483	0.107	20.361	1	<0.001	0.617
Constant	-4.531	0.422	115.161	1	<0.001	0.011
Nagelkerke R^2	.611					
Cut value	.715					

Table 3. Logistic Regression Model of Six-year Undergraduate Retention/Graduation, all Students

Variables in the Equation	STEM major first term (n = 2,038) B	$S.E.$	Wald χ^2	df	$Sig.$	Odds Ratio	Not a STEM major first term (n = 2,233) B	$S.E.$	Wald χ^2	df	$Sig.$
Underrepresented student (women and/or minority) (1 = yes)	0.688	0.166	17.250	1	<0.001	1.990	0.371	0.144	6.625	1	0.010
Number of years lived on campus while enrolled	0.508	0.069	54.954	1	<0.001	1.663	0.348	0.071	24.151	1	<0.001
Learning community member (1 = yes)	-0.033	0.158	0.043	1	0.835	0.968	-0.364	0.153	5.662	1	0.017
High school rank	-0.017	0.006	9.092	1	0.003	0.983	-0.015	0.004	11.962	1	0.001
ACT composite score	-0.080	0.023	11.957	1	0.001	0.923	-0.102	0.021	23.809	1	<0.001
Average load aid (x 1,000)	0.120	0.018	45.870	1	<0.001	1.127	0.105	0.016	44.747	1	<0.001
Average gift aid (x 1,000)	0.067	0.031	4.742	1	0.029	1.069	0.102	0.027	14.330	1	<0.001
Average work study aid (x 1,000)	0.560	0.169	10.926	1	0.001	1.750	0.762	0.176	18.764	1	<0.001
Average budgeted need (x 1,000)	-0.051	0.017	9.044	1	0.003	0.950	-0.070	0.016	18.349	1	<0.001
Cumulative GPA for LRT	3.080	0.164	350.757	1	<0.001	21.748	2.920	0.147	394.887	1	<0.001
Total high school language credits	0.042	0.030	1.882	1	0.170	1.043	-0.006	0.029	0.044	1	0.834
In-state student (1 = yes)	-0.734	0.172	18.230	1	<0.001	0.480	-0.779	0.164	22.631	1	<0.001
Started/remained a STEM major (1 = yes) [a]	0.166	0.166	0.997	1	0.318	1.181					
Started/remained a non-STEM major (1 = yes) [b]							0.683	0.233	8.586	1	0.003
Constant	-5.572	0.660	71.317	1	<0.001	0.004	-4.335	0.532	66.482	1	<0.001

[a] Compared with students who started as a STEM major, but were a non-STEM major as of last registered term.
[b] Compared with students who started as a non-STEM major, but were a STEM major as of last registered term.

	STEM major first term	Not a STEM major first term
Nagelkerke R^2/Cut value	.633	.597
Cut value	.715	.668

Table 4. Logistic Regression Model of Six-year Undergraduate Retention/Graduation for Students in STEM and non-STEM Majors Separately.

the researchers were: (a) campus residence in a residence hall room, suite, or apartment during their time at the institution, and (b) learning community membership during the first year, coded as learning community member = 1, not a learning community member = 0. Campus residence in every case was determined by the student's residence on the 10th day of classes for the given year. Because campus contracts generally were for the academic year, or 12 months in apartments, students who may have moved from campus housing later in the year were still counted as on-campus. The learning community experience at the institution is fundamentally a first-year experience, so participation was calculated for first-year participation only.

Also of interest for the study were the student's major and whether the major was in a STEM discipline, and whether there was a change from a STEM to non-STEM major or vice versa during the student's time at the University. Although the student's initial major was known, because multiple major changes might occur the researchers chose to use in the model students' majors during their last registered term at the University prior to graduation or leaving the University. For the first logistic regression model (Table 3), students staying in a STEM major were coded 1 and students who changed to a non-STEM major were coded 0. The final two logistic regression models (Table 4) separated STEM and non-STEM majors. For the first of these models, students who started in a STEM major and stayed in a STEM major were coded 1 and students who started in a STEM major and changed to a non-STEM major were coded 0. For the second of the separate logistic regression models, students who started in a non-STEM major and ended in a non-STEM major were coded 1 and students who started in a non-STEM major and changed to a STEM major were coded 0.

Information for the financial support variables was obtained from FAFSA form entries and Office of Student Financial Aid records. A six-year average of FAFSA financial information was used; only the years during which aid was received were used in calculating the average. To produce more interpretable estimates of the impact of the financial variables in both analyses, the values for each variable were divided by 1,000; interpretation thus was expressed in terms of the impact on student outcomes of retention/graduation or non-retention/graduation from a \$1,000 change in each financial variable. Following preliminary correlation analyses, all three measures of aid—average work study aid, average gift aid, and average loan aid—and average budgeted need over the six years of the study were included in the statistical analyses.

4. Results

Table 1 provides basic demographic information for the variables used in the logistic regression equations. Approximately 50% of the fall 2000 cohort were STEM underrepresented students (women or minorities). HSR (mean = 74th percentile) and ACT composite score (mean = 24.50) were employed to measure, respectively, the motivational and academic ability strengths that students brought with them to contribute to their academic success. Overall six-year retention/graduation for the cohort was 69%. Average loan aid for the six years was $5,100, average gift aid was $2,450, average work-study aid was $248, and average budgeted need was $4,830. Students in STEM majors accounted for 48% of the cohort studied. Seventy-three percent of students who started in a STEM major remained in a STEM major, but 92% of students who started in a non-STEM major remained in those disciplines.

Tests were conducted to determine whether statistically significant differences exist between the groups summarized in the table. The Pearson chi-square ($\chi 2$) statistic was used to test for differences in retention rates because retention is a categorical variable, and independent two-sample *t*-tests were conducted to assess possible differences for continuous variables (GPA, ACT, and HSR). Results were determined to be statistically significant when the *p*-value was less than .05 (indicating a Type I error rate of no more than 5%). Table 2 captures the retention rates and academic profile for the various student groupings that were part of the fall 2000 cohort. Students in STEM majors had statistically significantly higher HSR and ACT composite scores, as noted in the table. Students who were STEM majors their first academic term had significantly higher six-year retention/graduation rates than students who started out in non-STEM majors. More students in STEM majors changed to a non-STEM major ($N = 553$) than students in non-STEM majors changed to a STEM major ($N = 188$). It is noteworthy that students who initially were non-STEM majors and changed to a STEM major had a statistically significantly higher rate of retention/graduation compared to initially non-STEM majors who remained in non-STEM disciplines. In contrast, students who started out as STEM majors and changed to a non-STEM major did not have a statistically significantly higher rate of retention/graduation compared to initial STEM majors who remained in a STEM discipline. These findings partially support previous findings by Murphy (1999) and Micceri (2001) that students who change their major graduate at a higher rate than students who do not.

4.1 Model for All Students

The model predicting six-year undergraduate retention/graduation for all students fits the data well (Nagelkerke R^2 = .611) (Table 3). Data for all variables employed in the model were available for 4,174 students. The results presented below are based on findings from this number of observations; only 97 students were eliminated from the entire cohort due to missing data. The fit of the model was estimated using the cut value of .715, which is the percentage of all students who were retained or graduated in year six; using this cut value, the model correctly classified 82.3% (2,367 out of 2,877) of all students who graduated or were retained and 80.4% (1,043 out of 1,297) of all students who did not persist into or graduate by year six. Overall, 81.7% (3,410 out of 4,174) of all students were correctly classified as either retained/graduated or not retained/graduated. Of the cases not correctly classified, 254 students who had not been graduated or retained by year six were incorrectly predicted to have been successfully graduated or retained, and 510 who did graduate or were retained by year six were incorrectly predicted to have been unsuccessful. The 254 "outlier" cases of students who did not graduate or be retained are defined by having characteristics of successful students but not succeeding due to other variables not measured in this analysis. Similarly, the 510 "outlier" cases of students who did graduate or were retained had characteristics of unsuccessful students but nonetheless succeeded due to other variables not measured here.

Most of the variables in the logistic regression model were significant predictors of six-year retention/graduation. Long-term (six-year) retention/graduation is predicted most strongly by GPA during the student's last registered term. Because the magnitude of the odds ratio for this parameter estimate, 19.173, is affected by the interpretation based on a whole grade point unit difference (say, 3.00, compared to 2.00), it is somewhat easier to express its meaning in terms of a more meaningful smaller difference of one-tenth of a grade point unit (say, 3.10 compared to 3.00). The odds ratio for this parameter estimate can be interpreted to mean that, on average, students with GPAs one-tenth of a point unit higher are 91.73% more likely to graduate or be retained at year six than not graduate or be retained, controlling for the other predictor variables included in the model. This result suggests a very strong effect of higher cumulative GPA on retention/graduation, controlling for the effects of other predictors. It should be noted that for a logistic regression model in which cumulative GPA is considered alone as a predictor of student success, the comparable odds ratio is 12.048, indicating that a one-unit higher GPA (e.g., 3.00, compared to 2.00) is associated with a twelve-times higher rate of retention/graduation compared to not being retained or graduated with the lower GPA. Including each other predictor variable separately, together with GPA, does not appreciably change the odds ratio, which, however, does inflate in the presence of all predictors simultaneously. The fundamental substantive conclusion that cumulative GPA is the single strongest predictor of student success is not affected by these differences in model structure. Although this finding suggests a rather extreme effect of higher GPA on retention/graduation, the result is consistent in alternative probit models and using different mixes of predictor variables.

All four of the monetary variables in the model are significant predictors of six-year retention/graduation. Students with an additional \$1,000 of budgeted financial need are 5.8% less likely to graduate or be retained compared to students with \$1,000 less of budgeted need. Work study support is the strongest of the aid variables in the model; students with an additional \$1,000 of work study aid are 96.8% more likely to graduate or be retained, rather than not graduate or not be retained, compared to students with \$1,000 less of work study aid. An additional \$1,000 of loan aid is associated with an increase of 11.6% in the probability of graduation or retention by year six, and an additional \$1,000 of gift aid is associated with an increase of only 9% in the probability of year-six graduation or retention.

Students who are male and/or non-minority in STEM majors (that is, traditional or not underrepresented STEM majors) are about 74.6% more likely to be retained or graduate than to non be retained or graduate, compared to underrepresented (female and/or minority) STEM students, netting out the effects of the other variables included in this model. It is important to note that before adjusting for the presence of these other predictors in the model there was no statistically significant difference in the success rates for traditional and non-traditional STEM students.

The greater the number of years a student lived on campus is also significantly associated with greater success. For each additional year on campus, a student is 54.6% more likely to graduate or be retained by year six.

Both HSR and ACT composite test scores have significantly negative relationships with the probability of six-year retention/graduation. Together, these results indicate that in many cases higher-ability students start out in STEM disciplines, suffer a high rate of attrition, and subsequently are diverted into non-STEM disciplines. From Table 3, students with one percentage point higher HSR on average are 1.5% less likely to graduate or be retained after six years, and students with one point higher ACT on average are 9.1% less likely to be successful within six years.

Similar evidence is provided from at least one other research-heavy institution. Studies at the University of Minnesota (Jansen, Wambach, & Franko, 2005a, 2005b; Wambach, Hatfield, Franko, & Mayer, 2003) have found evidence that students entering that institution's General College with an interest in pursuing science, technology, engineering, and math (STEM) majors experience academic difficulty and many leave the University. Furthermore, a larger percentage of students leaving STEM majors had academic difficulty in science courses than did students who persisted in STEM. Many students with initial STEM interests became undeclared or undecided, which is worrisome given previous findings that those who remain undecided at transfer often experience further difficulties and tend to leave at a higher rate than students with declared majors (Jansen et al., 2005a).

Students who are out-of-state residents, on average, are significantly less likely than in-state residents to be successful academically by our measure of six-year retention/graduation. They are only 47.2% as likely to graduate or be retained than not to graduate or be retained, compared to in-state students. Students in non-STEM majors have significantly less success, with graduation/retention rates only 61.7% as high compared to students in STEM majors. This result may reflect stronger academic capability of students in the STEM major areas and more heavily funded support (such as learning communities with peer mentors and supplemental instruction) available to students in STEM majors.

4.2 Models for Initial STEM and Non-STEM Majors

The results presented in Table 4 summarize the findings from estimating separate models for the two subsets of students starting out their first semester in STEM and in non-STEM majors. These models are estimated with the same set of predictors, with the exception that the model for students starting out in a STEM major includes an indicator predictor variable distinguishing students who still were in a STEM major in year six from those who had changed to a non-STEM major, and the model for students starting out in a non-STEM major includes an indicator predictor variable distinguishing students who remained in a non-STEM major in year six from those who had changed to a STEM major.

The model for first-semester STEM students fits well, with Nagelkerke R^2 = .633, 81.1% of all non-retained/graduated students correctly classified, 84.4% of all successfully retained/graduated students correctly classified, and 83.5% of either successful or nonsuccessful students correctly classified. For students initially in a STEM major, the same predictors are significant, in the same direction, and to approximately the same magnitude as measured by odds ratios as for the cohort overall. Similarly, neither learning community participation nor high school language exposure was a significant predictor of retention/graduation. The newly-introduced predictor of whether the student remained in a STEM major or shifted out of a STEM discipline is not significant; thus, students who begin their undergraduate careers in a STEM major neither help nor hurt their chances for long-term graduation/retention success by choosing to remain with STEM or switching to a non-STEM major.

The corresponding model for students starting their first semester in non-STEM majors also fits the data well, with Nagelkerke R^2 = .597, 78.4% of all non-retained/graduated students correctly classified, 84.7% of all successfully retained/graduated students correctly classified, and 82.6% of either successful or nonsuccessful students correctly classified. The parameter estimates of this model also are similar in most respects to the model (Table 3) for all students and to the parallel results for first-semester STEM majors (Table 4). However, there are two noticeable, and important, differences. For students starting out in non-STEM majors, learning community participation has a statistically significant relationship with six-year graduation/retention success; non-STEM students who do not have the benefit of participation in a learning community experience are only 69.5% as likely to graduate or be retained at year six. In addition, whether an initially non-STEM student remains in a non-STEM major or switches to a STEM major is a significant predictor of six-year graduation/retention success; initially non-STEM students who switch to a STEM major have a 97.9% greater probability of six-year success than do students who remain in a non-STEM major.

5. Discussion

These research findings call attention to key demographic, environmental, and financial predictors of retention for STEM and non-STEM majors. The study also was focused on influences on the retention of underrepresented students in STEM majors, which was addressed in two separate regression equations. The initial regression model and the subsequent models separating students by major their first term (STEM or non-STEM) were strong, leading to confidence in the validity of the findings.

STEM majors demonstrated higher mean levels of ability than did their non-STEM counterparts, as measured by ACT composite score or HSR. Within the group of STEM majors, students who changed from STEM to non-STEM majors showed lesser ability (i.e., ACT composite and HSR) compared to those who did not change, and performed the least well of the four groups—(a) began STEM and stayed STEM, (b) began STEM and became non-STEM, (c) began non-STEM and switched to STEM, and (d) began non-STEM and stayed non-STEM—during the first year of school. Perhaps these students found the STEM majors to be too rigorous; however, we do not have direct evidence of their attitudes regarding the perceived degree of difficulty of their courses or majors.

The real or perceived difficulty of STEM majors has been the subject of previous research. Mundfrom (1991) found strong relationships between STEM disciplines and student perceptions of course difficulty (see also Mundfrom, Miller, & Shelley, 1992). Mundfrom, Shelley, and Miller (1992) concluded:

> In general, most of the courses which have a strong mathematical or technical basis are ranked among the top [most difficult] courses, while those courses whose contents are more closely associated with the arts, humanities, and consumer sciences are more prevalent in the lower half of the rankings.
>
> The concept of "course difficulty" appears to be real and verifiable in several ways. If such estimates were used by institutions of higher education, this could lead to improved advising and counseling of students concerning their selection of courses and the number of courses in which they should enroll. In view of Rasor's (1980) findings that students drop courses primarily because they are too difficult, such improvements in advising and counseling may have a direct

> effect on students' academic success and ultimately on their learning. [This] suggests that such improvements could also lead to more equitable admission standards and thereby improve the prediction of program success.

Lambert, Kinzie, and Cole (2009) have suggested that questions about academic difficulty are related to the critical national need to expand the representation of women and minorities in STEM. They found that the "most noteworthy gender difference was the influence of students' expected academic difficulty," and note that:

> Female STEM students may not get involved in educational activities because of a fear that they can only devote time to focused individual studying. If females and Latinas, in particular, are more affected by perceptions of how hard their major will be then educators need to emphasize activities that alleviate this stress or facilitate female student involvement in the supportive practices that they value.

That the impact of the perceived difficulty of STEM disciplines is a global concern is evident from the recent report of the Institution of Engineering and Technology (IET, 2008), which notes that the "alleged difficulty" of STEM course work tends to divert students from potential STEM majors and careers. The IET report also argues that the presumed greater difficulty of getting good grades in STEM courses is reinforced by adults and peers who influence students' academic decisions and is related to students' self-efficacy and degree of interest in different academic subjects. The report suggests a public awareness campaign "to raise the image of STEM subjects and careers, and change the impression of being difficult and 'out of reach' for most people." Students who had the highest achievement scores as judged by cumulative first-year grade point average stayed in their original major. In spite of this early achievement success, students who had changed their major were retained/graduated at the highest rate. Perhaps this indicates that students who were most driven to participate in their original major did the best in that first year, but only students who settled into a major for which they felt better-suited persevered the best. Of course, many students pick the right major the first time and stick with it.

It is not surprising that cumulative grade point average the final semester of enrollment was the strongest predictor of six-year retention and graduation, even when controlling for other variables in the equations. Especially noteworthy, however, is the dramatic effect of an average increase of as little as one-tenth of a percentage point in cumulative grade point average on six-year retention/graduation when controlling for all other predictors.

Financial aid measures (loan, gift, and work-study aid) were significant influences on six-year retention/graduation, undoubtedly showing the positive importance of financial support to students' success by reducing the need to seek burdensome and time-consuming jobs and freeing up time for study and learning. Average work-study aid showed the greatest influence of the three aid measures, likely because that form of assistance ties financial support with on-campus employment that further connects students with the academic environment (see Pascarella & Terenzini, 2005). It is noteworthy that aid packages trump budgeted need in predicting retention/graduation. Thus, it is aid dollars that are critically important in rectifying student financial need as the student progresses through the institution.

An important finding of this research is that students who are underrepresented in STEM fields (female or minority students) are significantly less likely to be retained or graduate within six years than to not graduate or be retained, compared to students who are the traditional STEM majors (male and non-minority students) when controlling for other variables such as financial loan, gift, and work-study aid. The effect is even more pronounced for STEM majors, perhaps due to the higher ability of those who start out in STEM disciplines. The benefits also are much higher for six-year retention/graduation for students starting out in non-STEM majors staying in a non-STEM major than for students initially in STEM majors remaining in a STEM major, likely due to the generally lower failure rates for students in non-STEM majors.

Additionally, students who live on-campus longer have a higher success rate (Astin, 1993; Blimling, 1993; Pascarella & Terenzini, 2005). Higher participation and social integration at the institution contributed to the higher persistence of on-campus students. Learning community participation is a significant predictor of retention/graduation success for students in non-STEM majors, but not for students who are STEM majors. Although learning community members are retained/graduated at a higher rate, our regression analyses control for other variables, such as academic ability and various aid packages that also influence academic success.

Students from outside the state are retained/graduated at a significantly lower rate than in-state students when controlling for other factors. This finding suggests that for out-of-state students to be successful, when they are distant from home, family, and established support mechanisms, greater institutional effort will be required to provide them with the assistance that is more readily available for students who are closer to home (and who pay usually much lower in-state tuition). Also, this study demonstrated that the completion of a greater number of high school language credits is not an indicator of higher academic ability or motivation that would lead to higher retention/graduation.

6. Conclusions and Limitations

Three research questions guided our investigation.

(1) *What background characteristics, ability measures, and financial and academic support mechanisms help explain six-year retention and/or graduation at the end of the sixth year?*

As shown in Table 3, the dominant predictor of six-year retention/graduation (unsurprisingly) was cumulative GPA for the last registered term. Other significant predictors of higher graduation/retention were years living on campus while enrolled and aid in the forms of loans, gifts, and (particularly) work study. To pursue the policy goal of increased retention and graduation for students in STEM undergraduate majors, clearly our evidence suggests that doing what is necessary to help students improve their grades and providing aid, particularly in the form of work study opportunities that connect students directly with the campus climate, must be top priorities.

Predictors of lower retention/graduation were underrepresented STEM student status (women and/or minority students), HSR, ACT composite scores, average budgeted need, being from out of state, and starting out one's academic career in a STEM major. From a policy perspective, these results suggest that efforts need to be undertaken to provide the support mechanisms appropriate for underrepresented students in STEM majors that tend to be available more-or-less automatically to traditional (white, male) students (i.e., study groups of students like themselves and organizational support through family STEM expertise, professional societies, and the like). Also, group living support for students enrolled in similar majors, such as residential learning communities or Greek houses, could prove helpful.

It is not simple to find ways to reduce the burden of budgeted need and the attendant necessity of working longer hours on jobs to help eliminate that financial gap, but institutions of higher education (IHEs) would be well advised to do what they can to reduce the need for student expenditures on tuition, fees, and room and board. That out-of-state students have less success creates a dilemma for IHEs that charge differential tuition, because they benefit from the higher tuition generated by recruiting more heavily beyond the state's borders but as a consequence of that recruitment strategy have lower rates of retention and graduation. A policy suggestion to reduce out-of-state recruitment and thus eliminate a tuition windfall is a non-starter; a more likely policy alternative is to enhance the institutional support, perhaps particularly work-study aid, that is targeted to students from out of state (and out of country), which would have the additional benefit of stimulating success among students who in many cases would have been recruited from out of state to diversify the demographic mix on campus and who therefore may be more likely to be in at-risk categories.

That students starting out in a STEM major are less successful at graduation/retention calls for more extensive and better-focused advising—both of prospective undergraduates in high school and middle school and of newly-matriculated students at IHEs who may be best advised not to pursue STEM majors if they do not have adequate preparation to address the rigor of those programs or advised to pursue a STEM major consistent with their abilities. Innovative programs providing support for the transition from high schools and community colleges into STEM majors also are essential for increasing students' success. The negative partial effects of higher HSR and higher ACT composite scores certainly do not argue for less attention to recruiting high-ability students; however, it is worthwhile to note that the significantly reduced graduation/retention rate among better-endowed students shown in these results is conditional on the presence of the other predictor variables included in the model, and reflects the additional need for early-intervention counseling for higher-ability students to consider alternatives to STEM majors in which they can apply their talents with greater success. Non-STEM departments on many campuses are delighted to welcome "diverted engineers" and other students who may have discovered that the STEM majors of their parents or siblings are not the only options available.

(2) *Are the predictors of six-year retention and/or graduation by the end of the sixth year different for STEM and non-STEM majors?*

The potentially moderating effect of whether a student started out in a STEM or a non-STEM major is summarized in Table 4. For students starting out their undergraduate careers in a STEM major, the fact that the results of their model are essentially identical to those of the model for students in STEM and non-STEM majors combined (Table 3) suggests that the policy directions and initiatives discussed for all students apply in roughly equal measure to those who begin with STEM. That conclusion is strengthened by the fact that outcomes for students who start out in a STEM major do not depend on whether students remain in a STEM major or move to a non-STEM area.

Clearly different policy recommendations are in order, however, regarding students who start out in non-STEM majors. Our results make it clear that such students would benefit significantly from strong learning communities. Furthermore, because students who initially are in non-STEM majors are more successful when they switch to a STEM major, a relevant policy recommendation is to provide early-intervention academic and peer advising to direct students with STEM-related talents into those majors.

(3) *Are underrepresented (female or minority) students in STEM majors more likely than traditional (majority male) students in STEM majors to be retained/graduated in six years when controlling for selected background, environmental, financial, and academic measures?*

Our results showing that underrepresented (female, and/or minority) students do not perform as well as traditional (white, male) students lead to the conclusion that new mechanisms are needed to attract and retain underrepresented students into STEM areas. This is the very point to major federal initiatives—primarily the National Science Foundation's and the U.S. Department of Education's separate STEM workforce development initiatives—to change the demographics of the STEM student corps (Butz et al., 2004; http://www.ed-msp.net/; http://www.nsf.gov). These current programs—and hopefully also future, better-funded and longer-term projects—can provide targeted funding for need-based financial aid as well as more traditional merit-based support for students majoring in STEM areas such as engineering, providing for heightened student enrollment and engagement through connecting community college and high school students with STEM career options through their local geographic communities, as well as through learning communities and similar group-based efforts that develop a sense of camaraderie in the shared adventure of STEM education.

We do not pretend that these results are definitive. Several limitations of our research data, and therefore of our findings, are important to note. Our results are based on an institution with a relatively homogeneous student population, measured by its ethnic mix and heavily in-state recruiting. Whether results would be substantially different in IHEs with more diverse student bodies is not known, but the lower success achieved by underrepresented STEM students is an effect that we expect would persist at many other institutions.

Our data come from a large land-grant institution that was bound by state law to accept any in-state student graduating in the upper half of her or his high school class. It may be reasonable to expect noticeably different results at institutions with greater admissions selectivity that are able to recruit students who are less likely to fail.

Learning communities are not uniformly available in all majors or at all IHEs; at some research-extensive IHEs they may be concentrated, for example, in colleges of engineering, while at traditional liberal arts institutions learning communities may be more deeply embedded in humanities and/or social science departments. A higher-impact role for learning communities in enhancing student success could be achieved by building out from the sometimes spotty success areas at any given institution to include other colleges and majors; as it is, it is difficult to sort out the effects of LCs when they are not equally available to students in all areas of STEM education.

In addition, we have not been able to measure the effects of other student support programs such as supplemental instruction, peer mentoring, or service learning, nor the possible interactions among these and other predictors. We strongly encourage continued research along these lines, to provide a firmer foundation for policy initiatives that will strengthen the success of students in STEM majors and thereby provide for a more diverse, successful, and secure future workforce in these critical areas of national and global need.

References

Agresti, A. (2002). *Categorical data analysis*. New York: Wiley.

Agresti, A., & Finaly, B. (2009). *Statistical methods for the social sciences*, fourth edition. Upper Saddle River, New Jersey: Prentice-Hall, Inc.

Anderson, E., & Kim, D. (2006). *Increasing the success of minority students in science and technology*. Washington, DC: American Council on Education.

Astin, A.W. (1993). *What matters in college? Four critical years revisited* (1st ed.). San Francisco: Jossey-Bass.

Astin A., & Astin, H. (1993). *Undergraduate science education: The impact of different college environments and the educational pipeline in the colleges*. Final Report. ED 362 404.

Astin, A. W., & Oseguera, L. (2005). Pre-college and institutional influences on degree attainment. In A. Seidman (Ed.), *College student retention: Formula for student success* (pp. 245–276). Westport, CT: American Council on Education and Praeger Publishers.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369-386.

Blimling, G. S. (1993). New challenges and goals for residential life programs. In R. B. Winston, Jr., S. Anchors, & Associates (Eds.), *Student housing and residential life: A handbook for professionals committed to student development* (pp. 1-20). San Francisco: Jossey-Bass.

Busch, T. (1995). Gender differences in self-efficacy and attitudes toward computers. *Journal of Educational Computing Research, 12*, 147-158.

Butz, W. P., Kelly, T. K., Adamson, D. M., Bloom, G. A., Fossum, D., & Gross, M. E. (2004). *Will the scientific & technical workforce meet the requirements of the federal government?* Santa Monica, CA: The RAND Corporation.

Cabrera, A. F., & La Nasa, S. M. (2000). Overcoming the tasks on the path to college for America's disadvantaged. *New Directions for Institutional Research, 107*, 31-43.

Carnegie Foundation for the Advancement of Teaching, the. (2005). The Carnegie classification of institutions of higher education. Retrieved May 30, 2009 from http://www.carnegiefoundation.org/classifications/index.asp?key=791

Cassell, G., & Slaughter, J. (2006). The challenge of the new demographics of higher education: Increasing women and minority participation in STEM disciplines. *Business-Higher Education Forum (BHEF) 2006 Issue Brief, 1-4.*

Chabrow, E. (2007). Numbers show big decline of women in IT. Retrieved June 29, 2009 from *CIO Insight* website, http://www.cioinsight.com/c/a/Past-News/Numbers-Show-Big-Decline-of-Women-in-IT/

Chubin, D., May, G., & Babco, E. (2005). Diversifying the engineering workforce. *Journal of Engineering Education, 94*(1), 73-86.

Culotta, E. (1992). Scientists of the future: Jumping high hurdles. *Science, 258*(5058), 1209-1213.

Daempfle, P. (2003). An analysis of the high attrition rates among first year college science, math, and engineering majors. *Journal of College Student Retention: Research, Theory and Practice, 5*(1), 37-52.

Desimone, L. (1999). Linking parent involvement with student achievement: Do race and income matter? *The Journal of Education Research, 93*(1), 11-29.

DesJardins, S. L., Ahlburg, D. A., & McCall, B. P. (2002). A temporal investigation of factors related to timely degree completion. *Journal of Higher Education, 73*(5), 555-581.

Erwin, L., & Maurutto, P. (1998) Beyond access: Considering gender deficits in science education, *Gender and Education, 10*(1), 51–69.

Felder, R., Felder, G., Mauney, M., Hamrin, Jr., C., & Dietz, E. (1995). A longitudinal study of engineering student performance and retention. III. Gender differences in student performance and attitudes. *Journal of Engineering Education, 84*(2), 151-163.

Fenske, R., Porter, J., & DuBrock, C. (2000). Tracking financial aid and persistence of women, minority, and needy students in science, engineering, and mathematics. *Research in Higher Education, 41*(1), 67-94.

Fischer, M. J. (2007). Settling into campus life: Differences by race/ethnicity in college involvement and outcomes. *The Journal of Higher Education, 78*(2), 125-161.

Flowers, L. A. (2004). Effects of living on campus on African American students' educational gains in college. *NASPA Journal, 41*(2), 277-293.

Graduation Rates (GRS). (n.d). In *The integrated postsecondary education data system glossary*. Retrieved May 29, 2009 from http://nces.ed.gov/ipeds/glossary/index.asp?id=812

Green, W.H. (2003). *Econometric analysis*. Upper Saddle River, NJ: Prentice Hall.

Henes, R. (1994). *Creating gender equity in your teaching*. College of Engineering, University of California, Davis.

Hill, S. (2007). *Science and engineering degrees, by race/ethnicity of recipients: 1995-2004.* Arlington, VA: National Science Foundation, Division of Resources Statistics (http://www.nsf.gov/statistics/nsf07308/tables/tab1.xls)

Hosmer, D.W., & Lemeshow, S. (2000). *Applied logistic regression*. New York: Wiley.

Hu, S., & St. John, E. P. (2001). Student persistence in a public higher education system: Understanding racial and ethnic differences. *Journal of Higher Education, 72*(3), 265-286.

Huang, G., Taddese, N., & Walter, E. (2000). *Entry and persistence of women and minorities in college science and engineering education*. NCES 2000-601. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Institution of Engineering and Technology. (2008). *Studying STEM: What are the barriers?* Available online: http://www.google.com/url?sa=t&source=web&ct=res&cd=8&url=http%3A%2F%2Fwww.theiet.org%2Fpublicaffairs%2Feducation%2Fstem.cfm%3Ftype%3Dpdf&ei=KAQjSq_7L4--NIvasKcJ&usg=AFQjCNE45JqjOZB7Z_eQQSADPLv_MV6E1w&sig2=fYWBMwGg467pbfgJrVzm_w. [Accessed May 31, 2009.]

Ishitani, T. T. (2006). Studying attrition and degree completion behavior among first-generation college students in the United States. *Journal of Higher Education, 77*(5), 861-885.

Jansen, E., Wambach, C., & Franko, J. (2005a). *1999 GC students with STEM major interests*. Twin Cities, MN: University of Minnesota General College.

Jansen, E., Wambach, C., & Franko, J. (2005b). *2002 GC cohort with STEM major interests: High school and college academic performance spring 2005*. Twin Cities, MN: University of Minnesota General College.

Lambert, A.D., Kinzie, J., & Cole, J.S. (2009, April). *First-year student engagement and STEM: Gender & racial-ethnic differences*. Presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Leppel, K. (2002). Similarities and differences in the college persistence of men and women. *The Review of Higher Education, 25*(4), 433-450.

McDonough, P. M. (1994). Buying and selling higher education: The social construction of the college applicant. *Journal of Higher Education, 65*, 427-446.

MacGregor, J., & Smith, B. L. (2005, May/June). Where are learning communities now? National leaders take stock. *About Campus, 10*(2), 2-8.

McShannon, J. (2001). *Gaining retention and achievement for students: A faculty development program to increase student success*. ED 450627.

Micceri, T. (2001). *Change your major and double your graduation chances*. Paper presented at the Association for Institutional Research Annual Forum, Long Beach, CA, June 3-6.

Milem, J. F., & Berger, J. B. (1997). A modified model of college student persistence: Exploring the relationship between Astin's theory of involvement and Tinto's theory of student departure. *Journal of College Student Development, 38*, 387-400.

Morrison, C., & Williams, L. (1993). Minority engineering programs: A case for institutional support. *NACME Research Letter, 4*(1), 156-167.

Mudroom, D.J. (1991). *Estimating course difficulty*. Doctoral dissertation. Ames, IA: Iowa State University.

Mundfrom, D.J., Miller, W.G., & Shelley, II, M.C., "An Application of Course Difficulty Estimates to the Prediction of Academic Achievement," presented at the American Educational Research Association Annual Meeting, April 1992.

Mundrom, D.J., Shelley, II, M.C., & Miller, W.G., "Perceptions of Course Difficulty," presented at the Winter Conference of the American Statistical Association, January 1992.

Murphy, M. (2000). *Predicting graduation: Are test score and high school performance adequate?* Paper presented at the Association for Institutional Research Annual Forum, Cincinnati, OH, May 21-24.

National Science Foundation, Math and Science Partnership Program, Directorate for Education and Human Resources. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5756&org=DUE&from=home. Viewed December 20, 2008.

Olenchak, F. R., & Hebert, T. P. (2002). Endangered academic talent: Lessons learned from gifted first-generation college males. *Journal of College Student Development, 43*(2), 195-212.

Pascarella, E. T., Pierson, C. T., Wolniak, G. C., & Terenzini, P. T. (2004). First-generation college students: Additional evidence on college experiences and outcomes. *Journal of Higher Education, 75*(3), 249-284.

Pascarella, E. T., & Terenzini, P. T. (1983). Predicting voluntary freshmen year persistence/withdrawal behavior in a residential university: A path analytic validation of Tinto's model. *Journal of Educational Psychology, 75*, 215-224.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research*. San Francisco: Jossey-Bass.

Pascarella, E. T., Terenzini, P. T., & Blimling, G. S. (1994). The impact of residence life on students. In C. C. Schroeder, P. Mable, & Associates (Eds.), *Realizing the educational potential of residence halls* (pp. 22-52). San Francisco: Jossey-Bass.

Ramsey, N., & McCorduck. (2005). Where are the women in information technology? Report of literature search and interviews for the National Center for Women & Information Technology, Boulder, CO. http://anitaborg.org/files/abi_wherearethewomen.pdf

Rasor, R. A. (1980). Why students drop classes and withdraw from American River College. (ERIC ED 184 654).

Reason, R. D., Terenzini, P. T., & Domingo, R. J. (2007). Developing social and personal competence in the first year of college. *The Review of Higher Education, 30*(3), 271-299.

Reid, R L. (2008). U.S. not meeting 'ambitious' goals for engineering graduates. *Civil Engineering, 78*(9), 25-27.

Robinson, M. (2003). Student enrollment in high school AP sciences and calculus: How does it correlate with STEM careers? *Bulletin of Science, Technology & Society, 23*(4), 265-273.

Rogers, J. M. (1993). *A program of deliberate psychological education for undergraduate females in engineering through role–taking*. Dissertation, North Carolina State University.

Seymour, E. (1995). Why undergraduates leave the sciences. *American Journal of Physics, 63*(3), 199-202.

Seymour, E. (2002). Tracking the processes of change in U.S. undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86*(1), 79-105. John Wiley, & sons. http://dx.doi.org/10.1002/sce.1044

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Singh, K., Allen, K., Scheckler, R., & Darlington, L. (2007). Women in computer-related majors: A critical synthesis of research and theory from 1994 to 2005. *Review of Educational Research, 27*(4), 500-533.

Springer, L., Stanne, M., & Donovan, S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21-51.

St. John, E. P. (1990). Price response in enrollment decisions: An analysis of the High School and Beyond Sophomore Cohort. *Research in Higher Education, 31*(2), 161-176.

St. John, E. P., Hu, S., Simmons, A. B., & Musoba, G. D. (2001). Aptitude vs. merit: What matters in persistence. *The Review of Higher Education, 24*(2), 131-152.

St. John, E. P., Kirshstein, R., & Noell, J. (1991). The effects of student aid on persistence: A sequential analysis of the High School and Beyond Senior Cohort. *Review of Higher Education, 14*(3), 383-406.

St. John, E. P., & Noell, J. (1989). The effects of student financial aid on access to higher education: An analysis of progress with special consideration of minority enrollment. *Research in Higher Education, 30*(6), 563-581.

Stage, F. K., & Hossler, D. (1989). Differences in family influences on college attendance plans for male and female ninth graders. *Research in Higher Education, 30*, 301-315.

Strenta, C., Elliot, R., Adair, R., Matier, M., & Scott, J. (1994). Choosing and leaving science in highly selective institutions. *Research in Higher Education, 35*(5), 513-547.

Takruri-Rizk, H., Jensen, K., & Booth, K. (2008). Gendered learning experience of engineering and technology students. *ACM SIGCAS Computers and Society, 38*(1), 40-52.

Tan, D. (2002). *Majors in science, technology, engineering, and mathematics: Gender and ethnic differences in persistence and graduation*. Retrieved October 28, 2008, from University of Oklahoma web site, Center for Student Affairs Research, http://www.ou.edu/education/csar/literature/tan_paper3.pdf

Terenzini, P. T., Cabrera, A. F., & Bernal, E. M. (2001). *Swimming against the tide: The poor in American higher education*. New York: College Entrance Examination Board.

Ting, S. R. (2003). A longitudinal study of non-cognitive variables in predicting academic success of first-generation college students. *College & University, 78*(4), 27–31.

Toulmin, C., & Groome, M. (2007). Building a science, technology, engineering, and math agenda. National Governor's Association: Washington, DC. ERIC Document Reproduction Service No. ED496324.

U.S. Department of Education, Mathematics and Science Partnerships Program http://www.ed-msp.net/. Viewed December 20, 2008.

Wambach, C., Hatfield, J., Franko, J., Mayer, A. (2003). *General college persisters and leavers: A comparative study*. Twin Cities, MN: University of Minnesota General College.

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