Making Academic Progress: The University of Michigan STEM Academy

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Abstract**:** In recognition of the critical need for an increased and diverse STEM workforce within the State of Michigan and nationally, the University of Michigan launched the Michigan STEM (M-STEM) Academy in the College of Engineering in the summer of 2008. M-STEM adapted features of the successful and nationally recognized Meyerhoff Scholars Program at the University of Maryland-Baltimore County, to develop a program serving a new clientele: talented diverse incoming engineering student who, for reasons of socioeconomic class, first generation college student status, race, gender, or lack of high school rigor might not be successful in pursuing a Michigan STEM degree. M-STEM provides these students with a highly coordinated support system during the critical transition years between high school graduation and the declaration of a STEM concentration by the junior undergraduate year. We will assess the program's impact on first-year grades (actual grades compared to predicted grades, based on background); the performance of this cohort within the context of a large engineering population and; the components of the first-year program associated with this achievement outcome. Our long-term goal for the M-STEM Academy Scholars is that they will complete their degrees with sufficient distinction to be highly competitive for admission to professional schools, graduate programs, or the workforce. Thus, our long term indicators include graduation rate, GPA, undergraduate research participation, summer internships, first position after graduation, and acceptance to professional or graduate schools. The program staff meets regularly to discuss the quantitative and qualitative indicators and how to use them to improve/modify program components including the content and mode of instruction in the summer transition courses, the frequency of academic coaching meetings, and the right combination of curricular and co-curricular programmatic efforts.

Introduction

The University of Michigan (UM) has a deep concern for the educational and human resource development of U. S. citizens in science, technology, engineering, and mathematics (STEM). Nowhere is the need for the creation of a highly trained and diverse technical workforce more evident than within the State of Michigan. For historical reasons in the 20th century, Michigan citizens did not need postsecondary degrees to secure remunerative and long-term employment. This is no longer the case. Michigan's unemployment rate now stands at 15.2%, the highest in the nation (GLITR 2009). The future of the State is critically dependent on the creation of an educated workforce, particularly one with high levels of expertise in science, engineering, and other technical fields (Duderstadt 2005). Building on a long history of

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academic excellence with a well-documented commitment to diversity, the University is critically reexamining its role in the creation of a 21st century STEM workforce.

For the past 3 years, faculty, staff and administrators representing a myriad of University of Michigan colleges and academic support offices have worked together to develop a holistic integrated curricular and co-curricular student development program to increase the number of students, including diverse students, who receive degrees in STEM fields. This extensive effort, entitled the University of Michigan STEM Academy (M-STEM*)*, was launched as a pilot program in the College of Engineering in the 2008-2009 academic year. Based on the successful and nationally recognized Meyerhoff Scholars Program at the University of Maryland-Baltimore County as well as the Biology Scholars Program (BSP) at the University of California Berkeley, M-STEM identifies talented diverse students with interest in STEM fields who, for reasons of socioeconomic class, first generation college student status, lack of high school rigor, race, or gender, might not be successful in pursuing a Michigan STEM degree. M-STEM provides these students with a highly coordinated support system during the critical transition years between high school graduation and the declaration of a STEM concentration by the junior undergraduate year. The 2008 pilot year of M-STEM had 47 College of Engineering (CoE) students, with 49 students following in a second 2009 cohort. This paper will outline the various programmatic aspects of the M-STEM Academy and discuss preliminary assessment findings.

The Michigan STEM Academic: Background, Rationale and Description.

The Michigan STEM Academy is based largely upon the successful Meyerhoff Scholars Program at the University of Maryland-Baltimore County (Summers & Hrabowski 2006; Hrabowski 2005; Gordon & Bridglall 2004; Maton & Hrabowski 2004; Maton, Hrabowski, & Schmitt 2000; Gándara & Maxwell-Jolly 1999). This initiative, founded in 1988, was designed to produce bachelor's degree recipients in STEM fields, particularly African Americans, who enter into doctoral programs. The program has found four critical core factors for success: (1) academic and social integration; (2) knowledge and skill development; (3) support and motivation; and (4) monitoring and advising. Key programmatic components include significant financial aid, a summer transition program, study groups, program values, program community, personal advising and counseling, tutoring, summer research opportunities, faculty involvement, and mentors. The Meyerhoff Scholars program has been extraordinarily successful. Students who entered the Meyerhoff program were twice as likely to earn a science or engineering bachelor's degree and 5.3 times as likely to enroll in post-college graduate study as compared to those students who were invited to participate but declined (Summers & Hrabowski 2006). Eighty-six percent of the Meyerhoff graduates earned science or engineering bachelor's degrees. As of 2006, 768 students have been Meyerhoff Scholars (Summers & Hrabowski, 2006). Another initiative which has many similar characteristics to Meyerhoff is the Biology Scholars Program at University of California Berkeley (Rey 2001; Matsui, Liu, & Kane 2003; Matsui 2009). What is significant about both of these programs is that they are guided by a strengths-based model. That is, they do not focus on remediating deficiencies, the hallmark of a deficits-based approach (Maton & Hrabowski 2004; Ford 2002; Steele 1997).

In 1996 the Meyerhoff Scholars Program expanded its admissions policy to include students of all races. A recent evaluation has indicated that changing from a race exclusive to an integrated program has been on the whole a positive experience for all students. Most importantly, the 1996-2000 African American students have been entering STEM Ph.D. programs at a much greater rate than those who preceded them, at a rate comparable to those of their European American and Asian American peers in the program, and at a rate greater than comparison sample students. This recent evaluation indicates that the core components of the Meyerhoff Scholars program, although developed for the success of African American students, appear to be equally valid for all students (Maton, Hrabowski & Ozdemir 2007). Other research studies have indicated that similar programmatic support mechanisms will work for other diverse students including first generation, low socioeconomic class, and non-rigorous secondary school preparation (Seymour & Hewitt 1997; St. John & Somers 1997; Jones 2005; Pascarella & Terenzini 2005; Nwankwo 2007).

Development of The University of Michigan STEM Academy Concept and Components: In the summer of 2006, a team of University of Michigan administrators, led by Senior Vice-Provost Lester Monts, attended the Summer Academy retreat in San Juan, Puerto Rico, sponsored by the Institute for Higher Education Policy. Immediately following this meeting, a team of six faculty and administrators from the University of Michigan College of Engineering, led by Associate Dean Anthony England, attended the Engineering Education Leadership Institute (EELI) Workshop in Bloomingdale, Illinois sponsored by Center for the Advancement of Scholarship on Engineering Education (CASEE) of the National Academy of Engineering. The primary concern of the Michigan teams at these two workshops was to develop a vision to ensure the success of a diverse undergraduate student population in engineering and science disciplines at the University of Michigan that is uncorrelated with economic, gender, ethnic, and cultural groups. As a first step in the implementation of this vision, it was decided that the College of Engineering would create a transition program that will foster the success of students entering through various K-12 pipelines. The result was the Michigan STEM Academy.

M-STEM Academy Components: It is important to note that the following M-STEM components are not a mere "shopping list" of optional opportunities for students, but rather an integrated package of resources that all M-STEM participants are required to use. They include the following:

Identification and Selection of Students: Faculty in the University of Michigan Center for the Study of Higher and Postsecondary Education are currently developing parameters to identify high potential students who, with the assistance of this program, will experience high levels of success in an undergraduate STEM concentration. A combination of high school GPA, SAT/ACT scores, Descriptor-plus neighborhoods, non-cognitive assessment, and variables garnered from the ACT Assessment designed to capture the level of academic assistance the students believe they need in college will be used to identify potential M-STEM students.

Summer Transition Program: All M-STEM students attend a pre-freshman six week summer transition program to prepare them explicitly for the new expectations and requirements of rigorous college courses. A new problem solving integrated mathematics/science course in the physical sciences has been developed and taught for two years in the pilot program. A similar course based in the life sciences is currently being developed. These courses prepare students for the rigor of the introductory courses in the freshman year. STEM career opportunities are presented; academic social networks are built; and social opportunities and cultural events add balance. This summer program is the first opportunity to promote social and academic integration.

Program Community (Living): M-STEM students live together during their freshman year in a single residence hall, thus maintaining a sense of community fostered during the pre-freshman summer program.

Advising and Academic Coaching: M-STEM staff, in coordination with the Engineering Advising Center, the LSA Advising Center, MEPO, and the WISE Program, monitor and support students on a monthly basis. Staff focuses not only on academic planning and success strategies, but also on any personal challenges students may have.

Peer Study Groups, Tutoring and Supplemental Instruction: Research strongly supports the value of study groups in STEM disciplines (Erickson & Stommer 2006). M-STEM scholars are expected to engage in peer group study. Peer group study starts during the summer transition program and continues throughout the students' undergraduate careers in the program. M-STEM staff provides students with coaching on how to study effectively in groups in order to maximize interaction while still maintaining individual responsibility for learning. In addition tutors are identified both within and outside the program. Lastly, supplemental instruction sessions are offered in several of the introductory mathematics, chemistry, physics and computer programming courses. The Science Learning Center and the Engineering Learning Center will work with M-STEM staff to facilitate this aspect of the program.

Research/Special Project Opportunities: M-STEM students have multiple opportunities to work in a research setting. Students may opt to participate in the Undergraduate Research Opportunity Program (UROP) during the academic year. In addition, M-STEM participants will have the opportunity for an academic research experience on the Michigan campus between the freshman and sophomore year coordinated by UROP and an off-campus academic experience between the sophomore and junior year. These off-campus experiences are tailored to meet the students' needs and interests and could include research internships in industry or federal labs, travel abroad programs, community service projects, or field studies. The Engineering Career Resource Center, the Career Center, the offices of International Programs in both LSA and Engineering, and individual STEM departments will work with M-STEM Academy staff and students to identify these opportunities.

Financial Aid: M-STEM students receive a $3,000 financial incentive for full participation in the M-STEM Academy and maintaining a B average in a STEM major. This is in addition to the financial aid package determined by the University of Michigan. The students receive $1,500 following the pre-freshman year summer program, recognizing that these students gave up summer employment opportunities in order to participate. The students receive $750 following the fall freshman semester and $750 following the winter freshman semester in an effort to allow the students to forgo employment and concentrate on the academics.

Mentors: M-STEM scholars are paired with mentors in their fields of study. These mentors are actively recruited from universities, private laboratories, government facilities and corporations. Michigan's huge alumni body in particular is used in this role. In addition, first year M-STEM students have a student peer mentor.

Evaluation: Ongoing assessment of student achievement in and engagement with the M-STEM program is critical to its success and to its potential contributions to knowledge of the field. A description is provided later in this paper.

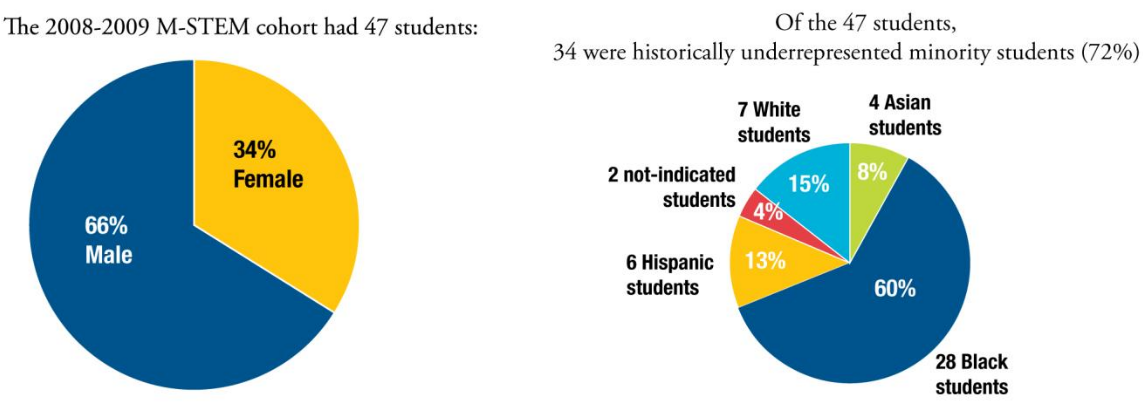
Post-M-STEM Activities: Following the completion of the sophomore year, M-STEM students will have declared their concentrations and will fall under the academic and student support services of their individual departments. Nonetheless, M-STEM staff will meet periodically with individual cohorts, both to maintain the sense of community developed during the first two years, but also provide group mentoring opportunities on professional and academic development issues. Michigan AGEP will be an important partner in this effort. In addition former M-STEM academy members will be engaged in outreach in the K-12 pipelines. Advanced M-STEM cohorts will also mentor incoming M-STEM cohorts.

Outcomes from the Implementation of the first M-STEM Pilot Year in the College of Engineering

Using a combination of funding sources including grants, gifts, endowed funds and college monies, the College of Engineering implemented the M-STEM pilot program in the spring of 2008 and again in the spring of 2009. The first two years have achieved measurably positive outcomes and are summarized below.

Demographics: Forty-seven students applied and were accepted to be members of the pilot program. Of these 47 students, 74% were historically underrepresented minority students and 34% were female. Many of them also were first generation college students, low socioeconomic class, and came from high school with less rigorous curriculums. The racial breakdown of the first M-STEM cohort can be seen in the chart below. The second M-STEM cohort had approximately the same breakdown in terms of majority/minority and male/female students.

DEMOGRAPHICS:



New Course: "Crossing the Boundary," a new integrated mathematics/science course was developed for the M-STEM summer transition program and now has been taught for two years. Although this class was designed to specifically prepare students to surmount the first hurdles to a STEM degree, specifically the introductory calculus and physics classes, the skills developed in this course are critical for a successful career in all STEM fields.   Physics and calculus courses are required prerequisites for all STEM fields at the University of Michigan. Historical data clearly show that many students from diverse backgrounds experience significant difficulty with these classes and that this often leads to attrition.   The integrated class is meant to level the playing field for students whose high school experience might not have included the necessary rigorous training needed to successfully complete these gatekeeper courses. Data also show that, if students can successfully complete these two courses, attrition is decreased in subsequent years for STEM majors.

A number of faculty from two colleges (Engineering and the College of Literature, Science & the Arts where engineering students take their introductory science and mathematics courses) were involved in the early development of the integrated course. These include Associate Dean James Holloway (Nuclear Engineering and Radiological Science), Professor Mark Banaszak Holl (Chemistry), Professor Laura Olsen (Molecular, Cellular and Developmental Biology); Professor Mark Hunter (Ecology and Evolutionary Biology and School of Natural Resources and the Environment), Professor Brad Orr (Physics and Applied Physics), and Professor Trachette Jackson (Mathematics). All of these faculty members have had extensive experience in course development and instruction of first and second year undergraduate students. Professor Guy Meadows (Naval Architecture and Marine Engineering and Faculty Director of the CoE M-STEM Program) expanded the early version of the course which he ultimately taught in the summer transition program. The course is currently being assessed.

Summer STEM-Related Experience Following the Freshman Year: The majority of the first M-STEM cohort had an academic-related summer experience between their freshman and sophomore years. Eighty-nine percent of the M-STEM students either had a corporate internship or a 10-week funded research project on campus. Generally only about 25% of CoE students have a STEM related summer experience at the end of their freshman year.

Assessment of Performance and Retention: Preliminary assessment in terms of grades and retention of the first pilot year of M-STEM is extremely positive. M-STEM students entered the college with slightly lower Math ACT scores than the average engineering student. Yet comparison of first year GPA's as well as performance in gateway mathematics, science, and engineering courses indicated that M-STEM students did as well if not better than CoE students as a whole. In addition we looked at underrepresented minority (URM) M-STEM students' achievement vs. the achievements of URM students not in M-STEM. See table below:

	M-STEM	CoE
ACT Math	27.7	30.0
ACT Comp	27.2	31.2
Average First Year GPA	3.029	3.156

	ACT Math	First Year GPA
M-STEM URM	27.4	3.065
Non-M-STEM URM	28.4	2.870

First-Year courses for M-STEM Students	Avg. GPA	CoE GPA
17 M-STEM students took Math 105	3.28	2.86
41 M-STEM students took Math 115	3.07	2.81
24 M-STEM students took Math 116	3.03	2.72
10 M-STEM students took Math 156 or above:	3.70	
46 M-STEM students took Eng 100:	3.19	3.21
41 M-STEM students took Eng 101:	3.02	3.26
9 M-STEM students took Physics 140:	2.57	2.73

38 M-STEM students took Chem 130:	2.72	2.98

In addition to these simple comparisons, Dr. Edward St. John, the Algo D. Henderson Collegiate Professor of Education, has collaborated with the CoE on the evaluation of the M-STEM pilot project and will continue to serve as external evaluator for the STEP project. Over the past 20 years, St. John has developed a "workable models" approach to the evaluation of interventions in higher education (St. John 1992, St. John 1995, St. John 1999; St. John & Musoba in press; St. John & Wilkerson 2006). He works within universities and state agencies to build cohort databases used to provide evaluations of interventions that aim to improve academic success, including degree completion. His research on the academic success of students in the CoE and the University of Michigan provides the foundation and framework for the evaluation plan. His early assessment of the first M-STEM cohort deserves a more detailed description. St. John has developed cohorts of entering UM and CoE students drawn from applications, student aid information, and registration data. Cohorts have been developed for freshmen entering in the fall terms of 2000, 2001, and 2005 and are being developed for the fall terms of 2007 and 2008. These data provide a baseline for comparing the groups over time and provide the basis for the evaluation methodology used for the project.

The analyses of the 2000 cohort were used as a source of information on the persistence gap at a planning meeting for the University of Michigan, "Cultivating Access and Success for Students of Color," hosted by the Institute for Higher Education Policy in Puerto Rico, July 17-21, 2006. This research revealed two reasons for the gap in persistence rates between majority and minority students: minority students dropped out at the same rate as low-income students during the first two years of college, indicating increases in grants could ease transitions; and *first year grades were the most significant variable in predicting persistence to degree after four years of college, indicating more attention should be paid to academic achievement during the first two years of college. At the planning meeting, Associate Deans for CoE and LSA developed a plan for a joint bridge program, an idea that became the core of the M-STEM Academy.*

After the CoE developed a pilot test of the M-STEM Academy, Professor St. John conducted studies of the first year grades of students in the first cohort. The co-directors of M-STEM noticed M-STEM students had high fall term grades and raised questions about whether this was likely because of the summer course. On the other hand, critics of M-STEM questioned whether high ability students were selected and that was the reason for the high grades. As a result, Professor St. John and his graduate students completed a comparison of actual grades to predicted grades based on entry characteristics. They used the 2000 cohort database based on background at entry (race, gender, and ACT scores) to predict first semester grades, then used the characteristics of M-STEM students to generated predicted grades, compared actual to predicted grades, and calculated the difference between actual and predicted first term grades based on entry characteristics. *We found that the predicted average GPA for the M-STEM students (based on race/ethnicity, income, residency status, and ACT/SAT score) was 2.881. The reported score of 3.221 was an average of .34 GPA higher, substantially higher than would have been expected GPA. In addition, based on background and expected GPA (the fall GPA based on entry characteristics), the estimated retention rates from year one to year two would be 97.28%, compared to an estimated 97.93% for the same students with their actual fall grades. This suggests an increased retention rate from year one to year 2 of approximately one-third FTE. Using expected grades, the rate of predicted persistence from year 2 to year 4 was 80.45%*

in the CoE (and 83.56% in the university, inclusive of major changes), compared to an estimated rate of 84.43% in the CoE (and 87.73% in UM) based on actual grades of M-STEM participants.

Next Steps and Conclusion

While preliminary assessment is encouraging, several questions remain:

- How do we identify the students who are most likely to benefit from this intensive and costly intervention?
- Which components of the M-STEM program are critical for success?
- Is the program scalable? The College of Engineering has between 1,200 and 1, 300 first year students annually
- Can the program components be successfully transferred to science and mathematics departments in other schools and colleges at the University of Michigan?
- How will students be supported (and will they need to be) as they transition out of M-STEM in their junior year and enter departments?
- Can the M-STEM program be used as a recruiting tool?
- Is the program sustainable and, if so, how?

We are current in the process of identifying the third cohort, finding research funding and positions for the second cohort between their freshman and sophomore year, and transitioning the first cohort into departments. We strongly believe that the Meyerhoff model can be used in large Research 1 University settings and will continue to work to ensure a diverse STEM talent pool for the state of Michigan and the nation.

References

Duderstadt, J.J. (2005). A Roadmap to Michigan's Future. http://milproj.ummu.umich.edu/publications/roadmap/index.html

Erickson, B.L. & Strommer, D.W. (2006). Inside the first-year classroom: challenges and constraints. In M.L. Upcraft, J.N. Gardner, B.O. Barefoot & Associates (Eds.), *Challenging & Supporting the First-Year Student,* San Francisco: Jossey-Bass.

Ford, D.Y. (2002). The recruitment and retention of African American students in gifted education: Beyond deficit ideologies. In S.J. Denbo & L.M Beaulieu (Eds.), *Improving Schools of African American Students: A Reader for Education Leaders*. Springfield, IL: Charles C. Thomas.

Gándara, P. & Maxwell-Jolly (1999). Priming the Pump: Strategies for Increasing the Achievement of Underrepresented Minority Undergraduate. The College Board, http://www.collegeboard.com/research/abstract/3877.html

GLITR (2009). Great Lakes IT Report, http://www.wwj.com/pages/4200206.php?

Gordon, E. W. and Bridglall, B. L (2004). Creating excellence and increasing ethnic-minority leadership in science, engineering, mathematics, and technology: A study of the Meyerhoff Scholars program at the University of Maryland, Baltimore County. Connoisseurial Evaluation Report, Learning Point Associates, www.learningpt.org.

Hrabowski III, F.A. (2005). Fostering first-year success of underrepresented minorities. In M.L. Upcraft, J.N. Gardner, B.O. Barefoot & Associates (Eds.), *Challenging & Supporting the First-Year Student,* San Francisco: Jossey-Bass.

Jones, W.T. (2005). The realities of diversity and the campus climate for first-year students. In M.L. Upcraft, J.N. Gardner, B.O. Barefoot & Associates (Eds.), *Challenging & Supporting the First-Year Student,* San Francisco: Jossey-Bass.

Maton, K.I., Hrabowski III, F.A. & Ozdemir, M. (2007). Opening an African-American STEM program to talented students of all races: evaluation of the Meyerhoff Scholars Program, 1991-2005. In G. Orfield, P. Marin, S.M.Flores & L.M Garces (Eds.), *Charting the Future of College Affirmative Action: Legal Victories, Continuing Attacks, and New Research*. The Civil Rights Project, http://www.civilrightsproject.ucla.edu/research/affirmativeaction/charting_aa.php

Maton, K.I., Hrabowski III, F.A. & Schmitt, C.L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching* 37(7), 629-654.

Maton, K.I. & Hrabowski III, F.A. (2004). Increasing the number of African American PhDs in the sciences and engineering. *American Psychologist* 59(6), 447-556.

Matsui, J. (2009). BSP in Retrospect: Understanding & Future Directions. Plenary Presentation at *Understanding Interventions that Broaden Participation in Research Careers* Conference, May 7-9, Bethesda, MD. http://www.understandinginterventions.org/index.php/plenary-session-presentations/

Matsui, J., Liu, R & Kane, CM (2003). Evaluating a science diversity program at UC Berkeley: more questions than answers, *Cell Biology Education* 2(2), 117-121.

Nwankwo, C. (2007). I'm Counting Every Penny. *Newsweek* August 27, 90.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: Vol. 2. A third decade of research*. San Francisco: Jossey-Bass.

Rey, CM (2001). Making room for diversity makes sense. *Science* 239, 1611-1612.

Seymour, E. & Hewitt, N.M. (1997). *Talking About Leaving: Why Undergraduates Leave the Sciences*, Boulder, CO: Westview Press.

Steel, C.M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. American Psychologist, 52(6), 613-629.

St. John, E. P. (1992). Workable models for institutional research on the impact of student financial aid. *Journal of Student Financial Aid, 22*(3), 13-26.

St. John, E.P. (1995). Rethinking tuition and student aid strategies. In E.P. St. John (Ed.), *Rethinking tuition and student aid strategies* (pp. 95-110). New Directions for Higher Education, No. 89. San Francisco: Jossey-Bass.

St. John, E. P. (1999). Evaluating state grant programs: A study of the Washington state grant programs. *Research in Higher Education, 40*(2):149-170.

St. John, E. P., & Musoba, G. D. (in press). *Pathways to academic success: Using research to inform reform: Analyses of Indiana's millennial cohort.* Albany, NY: SUNY Press.

St. John, E. P., & Somers, P. (1997). Assessing the impact of aid on first-time enrollment decisions. In J. S. Davis (Ed.), *Student aid research: A manual for financial aid administrators* (pp. 101-126). Washington, DC: National Association of Financial Aid Administrators.

St. John, E. P. & Wilkerson, M. (Eds.), (2006). *Reframing persistence research to support academic success*. 130. New Directions for Institutional Research. San Francisco: Jossey-Bass.
Summers, M.F. & Hrabowski III, F.A. (2006). Preparing minority scientists and engineers. *Science* 311, 1870-1871.