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## **AC 2011-1625: IMPROVING STUDENT RETENTION IN STEM DISCIPLINES: A MODEL THAT HAS WORKED**

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# **Improving Student Retention in STEM Disciplines: A Model That Has Worked**

## **Introduction**

In 2003, a cross-disciplinary committee of faculty, administrators, and advisors from the Colleges of Engineering and Applied Sciences (CEAS) and Arts and Sciences at Western Michigan University (WMU) identified a strategy to increase the number of Bachelor of Science graduates in science, technology, engineering, and mathematics (STEM) by improving the retention of first-time, first-year students majoring in STEM disciplines, with funding from the National Science Foundation (NSF). This Science Talent Expansion Program (STEP) project is a multi-faceted strategy that involves clustering first-time, first-year STEM students in discipline-specific learning community cohorts in both semesters the first year; developing an Engineering House which includes tutoring services for freshmen in the residence halls; enhancing academic and career advising; early intervention by faculty and residence hall staff for struggling students; and the formation of faculty learning communities for the exchange of best practices. Coordination of activities with other university programs such as the Louis Stokes Alliance for Minority Participation and freshman/parent orientation to promote student success was also improved. An institutional data-collection system was created to track student progress to support assessment and evaluation activities for this project. The tracking system provides a unique code for every student in the learning community cohorts; and compiles reports each semester to determine STEM course enrollment, performance (grade and overall GPA), and continuing enrollment in a STEM major. Written student surveys collect information about other project objectives. This paper discusses results from some aspects of the recently concluded 2003-10 STEP project effort, which has increased student retention and may be of interest to other universities. This work continues to evolve in a Phase 2 project initiated in Fall 2010.

## **STEP Project Background**

STEP has focused on first-time, first-year STEM students, with a primary focus on engineering and technology students, but with participation from other university STEM fields such as chemistry, mathematics, and physics. Through the collaboration established, a core group from CEAS and Residence Life has identified barriers to further improvement in retention and graduation for several target student populations. The first-time, first-year STEM students have diverse academic backgrounds. An example is first-semester mathematics enrollment. In Fall 2009, 9% of first-time first-year CEAS students were enrolled in Calculus II or higher, 34% in Calculus I, 28% in Pre-Calculus, 22% in Algebra II, and 8% in Algebra I or lower. Enrollment in first-semester mathematics in previous years was similar. Results of the current STEP project show that students enrolled in Pre-Calculus or Calculus during the first semester have higher 2<sup>nd</sup>-year retention to CEAS than students who are enrolled in Algebra II. For example, for the 2005 cohort, 70% of the students enrolled in Calculus or Pre-Calculus during the first semester were retained in CEAS, compared to 60% of the Algebra II students. First-time, first-year CEAS students, particularly those with weak mathematics preparation, continue to be a target group. Analysis of data for the latter portions of the 2008-09 and the whole of the 2009-10 academic years is ongoing, and is not entirely included in the results discussed in this paper.

Literature cites an intensified curriculum and increasingly difficult coursework among the reasons for the “slumping sophomores” phenomenon, which can contribute to disengagement from academic life.<sup>2,3</sup> At CEAS, returning sophomores who took Calculus during their first semester at Western Michigan University will be taking challenging engineering science courses. Sophomores who took Algebra II during their first semester will begin the challenging Calculus sequence. In order to improve overall retention rates beyond the first year, the returning sophomores form a target group, and are a major focus of Phase 2 of the STEP project, which has began in the Fall 2010 semester. Returning students are being tracked as part of the data collection efforts to determine retention data in the second and third year, and beyond.

The need for more STEM graduates, particularly from female and under-represented ethnic minority (URM) populations, is another focus of STEP, and forms an additional target group that we are working with in order to improve retention rates. In addition to STEP, these efforts include better coordination of activities with other university programs, such as the Louis Stokes Alliance for Minority Participation and freshman/parent orientation to promote student success in the target group. Increasing URM populations in CEAS through an aggressive recruiting effort strategically targeting high schools and community colleges, and combined with improved retention, can have an impact on this STEP program goal.

Faculty learning communities were formed for monthly meetings during the academic year to discuss reading materials (among many others) relevant to mentoring and student retention;<sup>4-8</sup> to coordinate professional development activities between student cohorts; and to share strategies for successful mentoring and early intervention with students who were struggling. Some outcomes of these faculty learning communities included: improvements in first-year STEM courses such as General Chemistry I with workshops on mathematics and study skills in chemistry, and in Technical Communication with career exploration as a theme for some of the writing assignments. A mathematics professor and a chemistry professor jointly developed a set of 68 problems that tie algebra skills to concepts in General Chemistry I. These problems are used in Algebra II, a prerequisite for placement into Chemistry I.

The number of students involved in the STEP program has increased steadily. Table 1 shows the increase in placement of students into learning communities, where first-time, first-year students take 3 to 5 courses in common with the same group of students (“a cohort”), to facilitate formation of study groups and other social or professional interactions. As much as possible, students in a cohort are also grouped by Residence hall staff in the Engineering House, which has enhanced STEM tutoring services available beyond the regular university tutoring or learning centers. Except for the base year of 2004-05, voluntary enrollment exceeded the expected or proposed enrollment projected by CEAS. Because the sample size from the 2004-05 year is small, retention data uses the 2005-06 cohort of students as the initial point of comparison.

Table 1. First-time First Year Students Placed in Learning Communities

	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Total
Actual	19	278	314	359	460	529	1959
Proposed	72	96	120	240	360	NA	888

## Western Michigan University Results from the STEP Retention Efforts

Although it is highly desirable to track and disaggregate the longitudinal data that has been collected so as to point towards the most beneficial aspects of the STEP program, it has not been possible to show which parts of the STEP effort have been most responsible for the increase in retention rates. Efforts have been undertaken in Phase 2 to do this, as will be discussed.

Results of the current STEP project (Table 2) show that students who participated have higher retention rates than students enrolled in Western Michigan University in general (cohorts retention rates verses University Baseline). This initial STEP effort, concluding after the 2009-10 academic year, increased the first-year retention rate to an average of 66% (through the 2008 cohort, as shown in Table 2; and 65% when including initial data analysis through 2009-10) from the college's historical baseline of 57%, which matched well with the University Baseline retention data (Table 2, reference a). The 65% retention rate exceeds the average of 62% for our peer institutions identified as "Moderately Selective" by the Consortium for Student Retention Data Exchange (CSRDE).<sup>1</sup> Fourth-year retention for students enrolled in the initial learning community cohort (2005) improved from the university baseline of 33% to 46%.

Table 2. Improvement in STEM Retention for Students in STEP Cohorts

CSRDE <sup>1</sup>	University Baseline <sup>a</sup>	Retention	2005 Cohort	2006 Cohort	2007 Cohort	2008 Cohort
69%	57.4%	2 <sup>nd</sup> Year	68%	70%	66%	66%
53%	42%	3 <sup>rd</sup> Year	54%	55%	52%	
NA	33%	4 <sup>th</sup> Year	46%	48%		
40.7% <sup>b</sup>	32% <sup>c</sup>	5 <sup>th</sup> Year	45.1% <sup>d</sup>			

<sup>1</sup> Data is for all institutions (Highly Selective, Selective, Moderately Selective, and Less Selective) as reported in the 2005-06 Consortium for Student Retention Data Exchange (CSRDE). Western Michigan University is a "Moderately Selective" institution. 2<sup>nd</sup> year retention and 6<sup>th</sup>-year graduation rate for "Moderately Selective" institution is 62% and 24%, as reported by CSRDE.

<sup>a</sup> CSRDE STEM Retention Survey, WMU Office of Student Academic & Institutional Research, data averaged 2000-05.

<sup>b</sup> 37.4% graduated in a STEM field in 6 years with another 3.3% returned the 7<sup>th</sup> year for a combined 40.7%.

<sup>c</sup> WMU Office of Student Academic & Institutional Research, data averaged 2000-03.

<sup>d</sup> As of the end of the 2009-10 academic year, 9.4% of the 2005 Cohort has graduated and 35.7% are continuing in the 6<sup>th</sup> year for a combined 45.1%.

As a part of institutional change, a formalized procedure was established among departments that teach first-year STEM courses to cluster students by learning community in both semesters of the first year. The objective of building a connection among students was validated by student responses to the written project survey in which 87% indicated in 2005 that they "agree" or "strongly agree" with the statement "I know at least 6 other learning community students," and 74% indicated they "agree" or "strongly agree" with the statement "I have studied with other learning community students." Responses in 2006, 2007, and 2008 were similar.

The percentages of female and under-represented ethnic minority (URM) undergraduates in CEAS, averaged over 2003-08, were ~12% and 10%, respectively, and below the national average of 18% and 15%.<sup>9</sup> The number of engineering and applied sciences B.S. degrees from Western Michigan University awarded to female and URM students, averaged over 2004-08, are 14.8% and 6.8%, respectively,<sup>10</sup> again below the national average of 18% and 12%.<sup>9</sup> The 2<sup>nd</sup>-year retention for female and URM CEAS students, averaged over 2005-08, of 71% and 65%, respectively, are substantially higher than the baseline retention (2004-05 academic year) of 50%

and 49%.<sup>10</sup> They are also higher than Western Michigan University's peer institutions ("Moderately Selective") as reported by CSRDE of 58% and 59%, respectively.<sup>1</sup>

### **Positive Institutional Changes from the STEP Project**

It is not possible to disaggregate the data to show which parts of the STEP effort have been most responsible for the increase in retention rates. The combination of initiating and tracking student cohorts, focusing on student success, enhanced student mentoring through faculty learning communities, and the collaboration of efforts between the college and the Residence Life programs, especially in the formation of a specific Engineering House, have proved successful. Changes within the institutional structure of the university have occurred to support and adopt practices initiated by the STEP project. Better access to student's academic records and the ability to identify struggling students have given faculty new tools to intervene much earlier with students who might not be retained in CEAS or within the university as a whole.

The STEP project has impacted positively on institutional policies to support student success, including:

1. Students sign a release form during Summer Orientation allowing the instructors of first-year STEM courses to provide in-semester progress reports to the STEP Principal Investigator (PI) and faculty mentors. Successful implementation of this early alert report led the Chair of the STEP Advisory Board to convince the Provost to adopt a mid-term grade reporting policy for the entire university, beginning in Fall 2006.
2. The Chair of the STEP Advisory Board persuaded the university administration to purchase software that interfaced with the university student information system. This allowed students to grant access to their parents or guardians to view registration and academic records beginning in 2007. This policy change allows the STEP mentors to enlist parents in supporting student success, since the current generation of students, The Millennials, look to their parents or guardians for advice and support.<sup>11</sup>
3. To improve 3<sup>rd</sup> year retention, the college has created a task force to improve learning in engineering sciences courses required by multiple college programs. Pilot programs in Statics, implemented in Fall 2008, and in Mechanics of Materials, implemented in Spring 2009, focus on student learning and include laboratory and computer software to help students visualize and understand difficult concepts.
4. Western Michigan University has become a partner in a multi-institutional NSF-CCLI Phase 3 project to improve engineering mathematics education. Since 50% of first-time, first-year STEM students are not Calculus ready in the first semester, this project addresses a barrier to further improvement in student retention. A pilot section of ENGR 1990, "Engineering Mathematics," was taught in Fall 2009 as the anchor class for a pre-calculus learning community. "A National Model for Engineering Mathematics Education" has demonstrated the success of this type of student support in improving student retention to engineering.<sup>12</sup>
5. Western Michigan University continues as a partner in a multi-institutional effort to increase the number of under-represented ethnic minority graduates in STEM funded by a NSF Louis Stokes Alliance for Minority Participation (LSAMP) grant. LSAMP includes undergraduate research, pre-first-year STEM programs, faculty mentoring of students, and faculty-student and student-peer social activities.

The STEP project has resulted in practices, processes, programs, and partnerships that will continue to support students' success and retention, beyond the life span of the original funding received from NSF in 2005.

### **Next Phase of this Project to Improve Student Success and Retention**

Planning for Phase 2 of the STEP project began in Spring 2010, and the first activities occurred during Summer and Fall 2010. An additional target population of students in Phase 2 are community college transfer students, and what they need to be successful in a STEM area of study after joining a 4-year university. Phase 2 expands the Engineering House to formally include sophomores and transfer students, and has initiated a summer bridge program focusing on math skills to improve students' fall semester math placement. Currently, 50% of first-time, first-year students are not ready to enroll in Calculus during their first semester. This slows their progress to degree as calculus is a pre-requisite for many other STEM courses. Increased collaboration with the Residence Life programs will involve STEM faculty working with resident assistants to provide programming for the Engineering House, especially in the areas of faculty expectations, discipline-specific professional development and career preparation, and academic advising.

Banta and Kuh<sup>13</sup> argued that “improving the quality of the undergraduate experience at any institution is so complex and multifaceted that it demands cooperation by the two groups on campus that spend the most time with students: faculty members and student affairs professionals.” However, “a faculty cannot by itself accomplish the college’s objectives for students’ intellectual and personal development; it needs the cooperation of others who work with students where students spend the majority of their time – in employment settings, playing fields, living quarters, and so on.” Collaboration with student affairs offers an opportunity for the college to move beyond the classroom and build on the current success.

While literature has been written on building collaboration between academic and student affairs,<sup>14-18</sup> true collaboration is still rare in institutions of higher learning. Barriers to collaboration between academic and student affairs can be attributed to background and training; a habit of isolation; differences in language, culture, and theoretical bases; poor communication; organizational structures, goals, and priorities; and a lack of mutual understanding.<sup>19,20</sup> True collaboration requires understanding the culture, language, and organizational characteristics as well as philosophical and programmatic approaches. It will also involve identifying the roles of faculty and student affairs staff in student development and the opportunities for interaction between the two units,<sup>21</sup> and joint planning, implementation, and accountability, and institutional commitment.<sup>22</sup> The purpose of collaborative partnerships between academic and student affairs is “to mutually construct the vision, goals, and processes for developing student learning experiences that integrate the emotional, social, and cognitive dimensions of learning.”<sup>23</sup> Cognitive learning models will be explored and integrated as part of the STEP Phase 2 project research activities, especially for programming developed in collaboration with Residence Life.

Additional efforts to disaggregate data collected on student success to be able to determine which specific aspects or activities of the ongoing STEP program are most beneficial to students has

already been undertaken as part of the Phase 2 effort. Most often, pre-enrollment factors, with emphasis on standardized test scores and high school grade point averages, have been considered. However, these measures may not be the only factors capable of forecasting success. In addition to using standardized test scores and high school grade point averages, the work at WMU is considering other pre-enrollment factors, and student activities once they enroll on campus. These factors include first-generation college student, math placement, and faculty mentoring; and academic or social factors, such as performance in math, science, and engineering courses; or engagement in Residence Life events through the Engineering House. The resulting retention model will be mapped against other non-successful engineering students for validation purposes.

## Conclusions

This initial effort, concluding after the 2009-10 academic year, increased the first-year retention rate to an average of 65% from the college's historical baseline of 57%. The 65% retention rate exceeds the average of 62% for Western Michigan University's peer institutions identified as "Moderately Selective" by the Consortium for Student Retention Data Exchange. Fourth-year retention for students enrolled in the initial learning community cohort improved from the baseline of 33% to 46%. The STEP project has made changes in the university, with several best practices regarding the tracking and analysis of student success being institutionalized. Efforts such as these could be transferred to other universities to enhance their own student success and retention programs activities. The project has motivated faculty and administrators to be more involved in multi-institutional efforts to improve programming for targeted student populations which has provided additional resources to assist students in being successful as they transition to college as first-time, first year students, and beyond. The Phase 2 effort just now getting underway will expand to include community college transfer students, and explore cognitive models of student learning as a way of integrating other activities into the student learning experience, especially through Residence Life, to further bolster the student success and retention efforts.

## Disclaimer and Acknowledgement of NSF Support



Support for the STEP program at Western Michigan University has been received from the National Science Foundation (NSF) Grant #0336581. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NSF.

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